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MANUAL

OF

CONCHOLOGY

STRUCTURAL AND SYSTEMATIC

WITH ILLUSTRATIONS OF THE SPECIES

VOL. XXII

ACHATINELLIDÆ

BY

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ASSISTED BY

C. MONTAGUE COOKE

GENEALOGY AND MIGRATIONS OF THE ACHATINELLIDÆ

BY

ALPHEUS HYATT

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PREFACE.

This volume treats of the tree snails of the Hawaiian Islands belonging to the family *Achatinellidæ;* those of the family *Amastridæ* (the genus *Laminella*) having been dealt with in Volume XXI, and arboreal forms of *Tornatellinidæ* (*Auriculella*) remaining to be considered in Volume XXIII of this series.

The *Achatinellidæ* hold an important place in general biological literature for the reason that a contribution of the first importance to the doctrine of evolution arose from a study of these snails. Gulick's theory of "divergent evolution through cumulative segregation" is now generally recognized as setting forth one of the conditions invariable for the "origin of species," having no necessary connection with natural selection, Lamarckian factors or mutation theory, but everywhere essential to speciation. For this reason, among others, the account of the group has been made somewhat more elaborate than usual in purely systematic treatises, in order that zoologists may be in a position to form intelligent ideas of the facts of distribution and variation of the group. It will readily be understood that having to cover the whole field, it was impossible to enter upon a detailed study of any single group of forms in a restricted area. The necessary limits of this work permit only brief discussion under each species. For an exposition of the facts bearing on evolution in general, a far more limited field should be chosen, two or three adjacent valleys, where the data could be made nearly complete. Even so, a certain amount of breeding under control would be essential to solid conclusions. As matters now stand, we infer where we should have exact knowledge.

The name of Dr. C. Montague Cooke is placed upon the title-page of this volume in recognition of his collaboration in elucidating the involved synonymy of the genus *Achatinella.* To the systematist this is perhaps the more important work of the vol-

ume. Indeed, the main features of this synonymy (excepting so much as had been recognized by earlier naturalists) were original with my colleague, having been worked out before we went over the ground together in Honolulu. While for the accuracy of the synonymy the senior author assumes equal responsibility with Dr. Cooke, it would be unfair to hold the latter responsible for the manner of presentation, or for the treatment of questions left in abeyance for want of time or type material in Honolulu. It was not practicable for my collaborator to go over the work in its final form; and for this reason many statements of fact or opinion throughout the text are made in the first person, especially when based upon material we had not gone over together. The determination of all forms of *Achatinella* believed to be new to science was also the joint work of both authors, as indicated in the text. Indebtedness to Dr. Cooke for various helpful suggestions relative to *Partulina* and other genera is acknowledged under the respective species. I may also be permitted to recall the comradeship which made the months spent in the Islands among the happiest of my life.

Information used in compiling the maps on pages 183, 277, and 341 was largely supplied by Dr. Cooke and Mr. Spalding.

Professor Hyatt's MS. descriptive of tree snails was not utilized in the preparation of this volume for the reason that his treatment of species could not be reconciled with the views herein expressed. Moreover, it is believed that had Hyatt visited the Islands and seen the actual association of forms, his ideas must have been very materially changed. Professor Hyatt's general results in phylogeny and zoogeography, so far as worked out at the time of his death, are given in an appendix (pp. 370–399), for comparison with the views developed in course of this study.

In order to keep this volume within reasonable size, an account of the soft anatomy of Achatinelloid snails and an appendix to volume XXI (*Amastridæ*) will form the first part of Vol. XXIII. That volume will also treat of *Auriculella*, *Tornatellina* and their allies, and contain a general index of all Achatinelloid snails.

The color nomenclature follows Ridgway's *Color Standards and Nomenclature*, except in the first two numbers, which were prepared before the publication of that work.

There remains the pleasant duty of thanking many friends who assisted in the preparation of this book. Acknowledgments are due the President and Trustees of the Bernice Pauahi Bishop Museum, who aided the author's work in the Islands by a generous grant. The Director and scientific staff of the Museum furthered the investigation at every point.

Messrs. Irwin Spalding of Honolulu and D. Thaanum of Hilo, Hawaii, placed their knowledge of Hawaiian shells and their splendid collections at the disposal of the author with such generosity as one meets but rarely in a lifetime.

To Professor Wm. Alanson Bryan, Messrs. R. A. Cooke, J. S. Emerson, Hon. L. A. Thurston, Mr. W. D. Wilder and others mentioned in the text, the author is deeply indebted for specimens used in this work, and for other favors which aided investigations.

The open-hearted hospitality of Hon. George C. Cooke of the Molokai Ranch enabled us to see far more of the Molokai fauna in a limited time than would have been possible under less ideal conditions.

Mr. E. A. Smith assisted with various notes on types in the British Museum, many of them figured for the MANUAL, under his critical eye.

Mr. H. W. Henshaw prepared an account of his observations on Hawaiian Partulinas (pp. 91–105) containing much important material.

Mr. C. W. Johnson lent a series of Gulick's type-specimens from the Boston Society of Natural History. Like favors were granted by Mr. Samuel Henshaw of the Museum of Comparative Zoology, where Pease's types are preserved, and by Professor G. D. Harris of Cornell University, custodian of the Newcomb collection.

Finally it should be said that the production of this work would not have been possible without the encouragement and support of the President of the Academy of Natural Sciences, Dr. Samuel G. Dixon, and of the Publication Committee, with Mr. S. Raymond Roberts, having the work in charge.

My warmest thanks to all of these friends and colleagues.

H. A. P.

PHILADELPHIA, *April*, 1914.

INTRODUCTION.

Family ACHATINELLIDÆ Tryon.

Achatinellidæ Tryon, 1884 (exclusive of *Tornatellinidæ* and *Amastridæ*).

Orthurethra with the kidney longer than the pericardium, oblong and narrow. Surface of the lung plain. Genitalia complicated by the presence of a long appendix provided with a branch from the penial retractor muscle. Spermatheca embedded in the prostrate gland, its duct long and simple; albumen gland minute; prostate gland enormously developed, composed of vermiform cæca. Jaw wanting or extremely thin, indistinctly plaited vertically. Radula broad and short. Teeth excessively numerous, arranged in V-shaped transverse rows; rake-like, composed of a narrow basal plate and a broad recurved portion bearing numerous unequal cusps.

The shell is more or less glossy, dextral or sinistral, oblong or ovate, minutely perforate or closed, composed of five to seven whorls, the last convex; aperture ovate; outer lip thickened or simple, sometimes expanding a little; columella usually bearing a strong, obliquely entering lamella in the last whorl; internal axis sinuous. No entering lamella or tooth on the parietal wall. Animal externally as in *Helicidæ*. Foot moderately broad, usually shorter than the shell. Viviparous.

Distribution, the Hawaiian Islands (except Kauai, Niihau and perhaps Kahoolawe). Living on trees and other plants.

Studies of the soft anatomy with abundant material have demonstrated, in my opinion, that the *Achatinellidæ* and *Amastridæ* are strongly distinct families. None of the many species of both, dissected by other naturalists or by myself, show the slightest approach in their differential characters.

The *Achatinellidæ* in essential structure stand nearest to the *Amastridæ*, *Enidæ* and *Ferussacidæ*, and are somewhat

more remotely related to *Partulidæ*. The structure of the pallial organs and kidney is very similar in the first three of these families. The male reproductive organs also, while differing in details, are much alike, having features widely prevalent in the lowest land snails, also in *Onchidium*, etc.

Partula, by lacking an appendix on the penis, and also by the simple prostate gland and the somewhat different form of kidney, stands a little apart.

By the structure of the female reproductive system, the *Achatinellidæ* are most nearly akin to the *Amastridæ*, but are more evolved by the reduction of the albumen gland to a minute rudiment, the prostate being at the same time enormously enlarged. The difference between the two families in this character is one of degree rather than of kind.

From all other families mentioned above, the *Achatinellidæ* differ strikingly in dentition. Those families have teeth of normal shape, with cusps resembling and homologous with these of the *Helicidæ*, *Lymnæidæ*, and most other Pulmonate snails. The teeth of *Achatinellidæ* and *Tornatellinidæ* differ strikingly by having basal-plates of a different shape; and their cusps are not recognizably homologous with those of other land snails. Moreover, there is no division into lateral and marginal areas of the radula with different forms of teeth.

Morphology of Achatinellid teeth.

It is well known that arboreal snails usually have the teeth specially modified, more or less unlike those of their nearest relatives among ground snails. *Liguus* and *Polymita* are notable examples, but in many others, such as *Drymæus, Papuina*, etc., a process of change is evidently in progress. In all of these genera, the cusps, though variously changed, are still clearly homologous with those of normal teeth. Without committing ourselves to any special hypothesis of how such changes come about, we cannot avoid the conclusion that in some way the nature of the food or the conditions of grazing lead to adaptive remodelling of the teeth in arboreal snails. So long as the modification does not affect the homologies of

the cusps, it is not necessarily of much systematic importance. The amount of change in various groups is apparently some indication of the length of time since arboreal habits were assumed. In *Achatinellidæ* and *Tornatellinidæ* the modification of the teeth is wholly unlike that usual in arboreal snails of other families, in which the cusps are always broadened. The *Achatinellid* type is really a further development of the multicuspid teeth of small ground snails, and it would seem, not an adaptation induced by arboreal life, though it has obviously proved efficient in that station, in the absence of any competitors.

The multicuspid cutting edges of the teeth, and the absence of differentiation into laterals and marginals, cause me to view the Achatinellid radula as one from which *central and lateral teeth have been eliminated*, leaving only marginals. The marginal teeth of *Amastridæ* and *Enidæ*, as of many other snails, stand in somewhat oblique transverse series. If the median field was eliminated, the transverse rows would be broadly V-shaped. *Pachnodus* in the *Enidæ*, as figured by F. Wiegmann, has somewhat such a radula as that we may suppose the ancestors of *Achatinella* had. The teeth of *Pachnodus* are very numerous, 375 to 393 in a row, the marginal fields have the rows strongly oblique, and the marginal teeth are multicuspid. The teeth of *Achatinella* differ from the marginals of *Pachnodus*, or of *Leptachatina*, chiefly by the long and narrow basal-plate, whereas in most marginal teeth this plate is very short and broad.

By a similar reduction, some species of *Mesomphix* have practically eliminated the lateral teeth, while others retain a few of them. The closely related *Omphalina* has the usual development of laterals. The *Agnatha* and *Agnathomorph* snails also have lost all laterals.

I believe, therefore, that all the teeth of *Achatinellidæ* have been derived from the marginals of some unspecialized group of ground snails having multicuspid marginal teeth. This ancestral group was evidently also ancestral to the *Amastridæ*, in which *Leptachatina* still retains multicuspid marginal teeth; but even the most primitive existing *Amastridæ* have

so far specialized the dentition that it seems to me quite impossible that *Achatinella* could have been derived from any Amastrine genus now living.

The teeth of *Physidæ* may be a similar evolution from the marginal teeth of some Basommatophorous stock. They have a remarkable superficial resemblance to those of the *Achatinellidæ*. The *Athoracophoridæ* have also evolved teeth wonderfully similar to those of *Achatinella*. This is evidently a case of convergent evolution, as the relationship must be remote.

Notwithstanding its strong differential characters, the family is a very compact one, with remarkably little structural variety for a group so prolific in species. Most genera of Helices show much greater specific diversity in characters of the soft parts than I have been able to find in the whole family of *Achatinellidæ*. There has been no adaptive radiation, and with the possible exception of *Newcombia*, there are no aged or phylogerontic branches.

This contrasts with the *Amastridæ*, which have been adapted to a variety of stations, humid, semiarid and arboreal, and in which the shell varies from cylindric or turrited to discoidal, with wide diversity in sculpture, color and solidity.

It appears that the *Achatinellidæ* are a still youthful group in the full flower of their evolution, probably derived from some plain terrestrial form which was rejuvenated by the discovery of a new station—the leaves and branches of trees.

Fossil *Achatinellidæ* known up to this time are all of Holocene, or perhaps in part of Pleistocene age. They are far less numerous than fossil *Amastridæ*, probably because the deposits wherein land shells are preserved lie mainly close to the sea, while *Achatinellidæ* are shells of the mountain forests. The known fossil species follow.

Achatinella phaeozona Gul. Kailua (p. 187).
Achatinella cæsia littoralis P. & C. Kahuku (p. 266).
Partulina montagui Pils. Manoa Valley (p. 66).
Partulina dwighti occidentalis P. & C. Molokai (p. 361).
Newcombia philippiana Pfr. Molokai (p. 356).
Partulina confusa Sykes. Hawaii (p. 105).

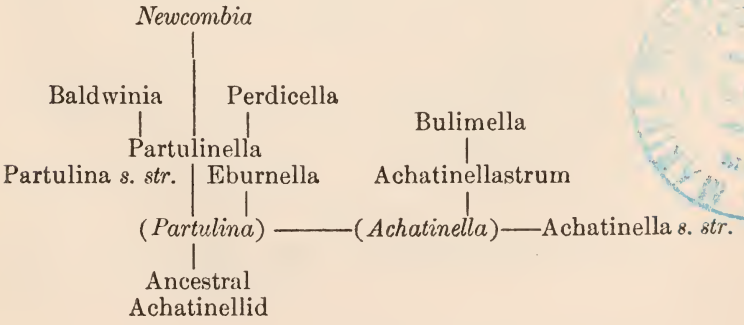
Partulina montagui is a very distinct species, but not in the least primitive in character. Two other extinct forms are distinguishable races of living species, while the other three found fossil do not seem to differ from modern shells.

Further extinct species are to be expected in comparatively high beds, such as the Manoa and Palihoukapapa forest deposits. Many such must exist, and they may afford a good deal of light on such obscure questions as the part taken by *Partulina* in the ancient Oahuan fauna.

Classification of Achatinellidæ.

It has been stated above that the genera and subordinate groups of *Achatinellidæ* are based entirely upon characters of the shell. The soft anatomy, so far as known, is practically alike in all. The genera are not groups of much systematic importance—not more I should say, than the "sections" established in my monograph on *Partula*; but they are obviously natural groups, which have been found useful in dealing with long series of species.

The family divides primarily into two groups, *Partulina* and *Achatinella*. By their coloration and sculpture, *Newcombia, Perdicella* and *Baldwinia* are obviously derivatives of *Partulina*. The *Partulina* group is more numerous in species and far more varied in structure than *Achatinella*, which consists of three very closely related sections. *Eburnella* is a group of uncertain affinities, but apparently linked to *Partulina* by certain species of Maui and Lanai. The approximate relationships of the groups are represented in the following diagram.



Key to Genera and Sections of Achatinellidæ.

a. Columella straight or only weakly folded.

b. Shell slender, turrite, usually sculptured; 3⅓ embryonic whorls, having coarse spirals, the last obliquely striped. NEWCOMBIA, p. 1.

*b*¹. Shell oblong or ovate.

c. Shell striped or tessellated, sometimes banded, small, usually less than 17 mm. long. *Perdicella*, p. 15.

*c.*¹ Shell zigzag striped, banded or white, usually well over 17 mm. long, or if so small, the last whorl is unusually large. *Baldwinia*, p. 90.

*a*¹. Columella strongly folded.

b. Shell dull or polished, usually with distinct spiral striation; the embryonic shell biconic, often striped; usually two or several embryos in the uterus at one time. PARTULINA, p. 14.

c. Shell small, tessellated or striped, columellar fold thin. *Perdicella*, p. 15.

*c*¹. Shell larger, spirally striate, columellar fold stout. *Partulina, s. str.*, p. 23.

*c*². Shell polished, often banded, columellar fold stout. *Eburnella*, p. 67.

*b*¹. Shell polished; spiral striation weak or almost wanting; embryonic shell short and broad, its last whorl never striped obliquely; only one well-developed embryo in the uterus at a time. Oahu: ACHATINELLA, p. 117.

c. Outer lip thickened by an internal callous ridge; shape oblong-conic or ovate, summit obtuse. *Bulimella*, p. 118.

*c*¹. Outer lip but little or not thickened within, not expanded; summit conic, the embryonic whorls not conspicuously flattened. *Achatinellastrum*, p. 180.

*c*². Outer lip thickened within; shape globose-conic; embryonic whorls almost flat. *Achatinella, s. str.*, p. 274.

Systematic List of species and subspecies of Achatinellidæ.

Numbers following the species refer to pages where they are described. In *Partulina*, where there are several collateral phyla, no linear arrangement can be made which will show the affinities with *Newcombia* and *Achatinella*, and at the same time preserve a logical sequence of groups and species within the genus.

Genus NEWCOMBIA Pfeiffer.

(Molokai)

N. plicata Migh., Pfr. 2.
N. p. gemma Pfr. 3.
N. sulcata Pfr. 5.
N. canaliculata Bald. 6.
N. c. wailauensis Pils. 7.
N. philippiana Pfr. 8, 356.
(+ *perkinsi* Sykes)

(Molokai)

N. pfeifferi Newc. 13, 355.
N. p. ualapuensis Pils. 12.
N. p. cinnamomea Pfr. 10.
N. p. decorata Pils. 12.
N. p. honomuniensis Pils. 12.

(Maui)

N. cumingi Newc. 10.

Genus PARTULINA Pfeiffer.

Section *Perdicella* Pease.

(Molokai)

P. helena Newc. 16, 356.

(Maui)

P. ornata Newc. 18.
P. zebra Newc. 19.
P. mauiensis Pfr. 20.
P. zebrina Pfr. 20.
P. fulgurans Sykes 21.
P. carinella Bald. 7, 358.
P. thwingi P. & C. 357.
P. kuhnsi Pils. 22.

Section *Baldwinia* Ancey.

(Hawaii)

P. confusa Sykes 105.
P. horneri Bald. 107, 365.
P. h. candida P. & C. 365.
P. h. fuscospira P. & C. 365.
P. h. fuscozonata P. & C. 365.
P. physa Newc. 109.
P. p. errans Pils. 111.
P. p. konana P. & C. 365.

(Maui)

P. grisea Newc. 111.
P. thaanumiana Pils. 112.

(Oahu)

P. dubia Newc. 113.

Section *Partulina* Pfr., *s. str.* (*Molokai*).

P. virgulata Migh. 25, 358.
P. v. halawaensis Borch. 27, 359.
P. v. kaluaahacola P. & C. 359.
P. subpolita Hy. & Pils. 359.

Section *Partulinella* Hyatt (p. 392).

(Molokai)

P. tessellata Newc. 28, 360.
P. t. meyeri Borch. 29.
P. rufa Newc. 29, 360.
P. proxima Pse. 32, 360.
P. p. schauinslandi Borch. 33.
P. p. multistrigata Pils. 34, 360.
P. theodorei Bald. 33, 360.
P. dwightii Newc. 35, 360.
†P. d. occidentalis P. & C. 361.
P. d. mucida Bald. 34, 361.
P. redfieldii Newc. 38, 362.
P. r. kamaloensis P. & C. 362.

(Oahu)

† P. montagui Pils. 66.

(Lanai)

P. crassa Newc. 40, 362.

(Maui)

P. kaaeana Bald. 41.
P. ustulata Gul. 47, 362.
P. marmorata Gld. 42.
P. plumbea Gul. 43.
P. winniei Bald. 44.
P. perdix Rve. 45, 363.
P. induta Gul. 48.
P. radiata Gld. 49, 363.

* * *

P. splendida Newc. 51, 363.
P. s. baileyana Gul. 52.
P. gouldii Newc. 52.

* * *

P. tappaniana C. B. Ad. 54.
P. t. ampulla Gul. 57.
P. t. eburnea Gul. 57.
P. t. carnicolor Bald. 58.
P. nivea Bald. 59, 363.
P. dolei Bald. 60, 364.
P. lemmoni Bald. 61.
P. terebra Newc. 61, 364.
P. t. attenuata Pfr. 63.
P. t. longior Pils. 63.
P. t. lignaria Gul. 63.
P. fusoidea Newc. 64.
P. crocea Gul. 65.

Section *Eburnella* Pease.

(Maui)

P. mutabilis Bald. 68.
P. porcellana Newc. 69.
P. p. flemingi Bald. 71.
P. p. wailuaensis Sykes 72.
P. p. fulvicans Bald. 73.
P. nattii Bald. & Hartm. 73.
P. anceyana Bald. 75.
P. germana Newc. 76.

(Lanai)

P. variabilis Newc. 83.
P. v. lactea Gul. 86, 364.
P. semicarinata Newc. 86.
P. s. hayseldeni Bald. 88.

(Molokai)

P. mighelsiana Pfr. 77.
P. m. bella Rve. 79.
P. m. polita Newc. 80.

Genus Achatinella Swainson.

Section *Bulimella* Pfeiffer (Oahu).

A. abbreviata Rve. 123.
A. viridans Migh. 125.
A. tæniolata Pfr. 130.
A. byronii Wood 133.
A. b. rugosa Newc. 135.
A. b. waimanoensis P.&C. 137.
A. b. nigricans P. & C. 138.
A. lila Pils. 139.
A. pulcherrima Sw. 140.
A. p. nympha Gul. 144.
A. decipiens Newc. 145.
A. d. planospira Pfr. 147.
A. d. kaliuwaaensis P.&C. 150.
A. d. swainsoni Pfr. 150.

* * *

A. rosea Swains. 151.
A. bulimoides Sw. 154.
A. b. mistura P. & C. 156.
A. bulimoides spadicea P.&C. 157.
A. b. obliqua Gul. 158.
A. b. ovata Newc. 160.
A. b. rotunda Gul. 163.
A. b. glabra Newc. 164.
A. elegans Newc. 166.
A. e. wheatleyana P. & C. 168.

* * *

A. fuscobasis Sm. 170.
A. f. lyonsiana Bald. 172.
A. f. wilderi Pils. 173.
A. pupukanioe P. & C. 174.
A. sowerbyana Pfr. 175.
A. s. thurstoni P. & C. 177.
A. s. laiensis P. & C. 178.
A. s. dextroversa P. & C. 179
A. s. roseoplica P. & C. 180.

Section *Achatinellastrum* Pfr.

(Main range of Oahu)

A. phæozona Gul. 184.
A. buddii Newc. 187.
A. fulgens Newc. 190.
A. f. versipellis Gul. 196.
A. f. ampla Newc. 198.
A. solitaria Newc. 204.
A. stewartii Green 204.
A. s. producta Rve. 207.
A. vulpina Fér. 212.
A. v. colorata Rve. 224.
A. v. tricolor Smith 226.
A. bellula Smith 230.
A. b. multizonata Bald. 231.
A. casta Newc. 235.
A. casta margaretæ P.&C. 240.
A. juncea Gul. 241.
A. papyracea Gul. 243.
A. juddii Bald. 244.
A. livida Swains. 246.
A. l. emersoni Nc. 247.
A. l. recta Nc. 248.
A. l. herbacea Gul. 251.
A. curta Newc. 252.
A. dimorpha Gul. 258.
A. cæsia Gul. 263.
† A. c. littoralis P. & C. 266.
A. c. cervina Gul. 267.
A. c. cognata Gul. 267.

(Waianae range)

A. spaldingi P. & C. 271.
A. lehuiensis Smith 271.
A. l. gulickiana P. & C. 273.
A. thaanumi P. & C. 273.

Section *Achatinella* Swains., *s. str.*

(Main range of Oahu)

A. lorata Fér. 278.
A. l. nobilis Rve. 283.
A. l. pulchella Pfr. 284.
A. cestus Newc. 286.
A. vittata Rve. 289.
A. v. cinerea Sykes 291.
A. v. simulans Rve. 292.
A. turgida Newc. 294.
A. t. perplexa P. & C. 296.
A. t. ovum Pfr. 297.
A. t. simulacrum P. & C. 299.
A. t. cookei Bald. 300.
A. leucorraphe Gul. 301.
A. l. irwini P. & C. 302.
A. swiftii Newc. 306.
A. s. chromatacme P.&C. 316.
A. s. dolium Pfr. 316.
A. apexfulva Dixon 317.
A. a. vespertina Bald. 322.
A. a. alba Sykes 324.
A. a. apicata Newc. 324.
A. a. beata P. & C. 329.
A. a. aloha P. & C. 330.
A. decora Fér. 331.
A. valida Pfr. 334.
A. v. leucophæa Gul. 336.
A. v. cinerosa Pfr. 336.
A. v. kahukuensis P. & C. 338.

(Waianae range)

A. mustelina Migh. 342.
A. m. sordida Newc. 349.
A. m. lymaniana Bald. 350.
A. concavospira Pfr. 351.
A. c. turbiniformis Gul. 353.

Incertæ sedis.

A. aptycha Pfr. 54, 145, 363.

DISTRIBUTION OF GENERA, SUBGENERA AND SPECIES.

ISLANDS	NEWCOMBIA	PARTULINA				ACHATINELLA			Totals by islands
		Perdicella	Partulina	Baldwinia	Eburnella	Bulimella	Ach'astrum	Achatinella	
Niihau	. .	. .	. .	. .	. .	. . .	. . .	. . .	. .
Kauai	. .	. .		. .			. . .	. . .	. .
Oahu	. .	. .	1	1		13	17	11	43
Molokai	5	1	8	. .	1	. . .	. . .	. . .	15
Lanai	. .	. .	1	. .	2	. . .	. . .	. . .	3
Maui	1	8	14	2	6	. . .	. . .	. . .	31
Kahoolawe	. .	. .	. .	. .	. .	. . .	. . .	. . .	. .
Hawaii	. .	. .	. .	3	. .	. .	. . .	. . .	3
Total no. of species.	6	9	24	6	9	13	17	11	95

N. B. No species is common to two islands.

COLOR PATTERNS OF ACHATINELLIDÆ.

The primitive color pattern of arboreal *Achatinellidæ* may have consisted of dark streaks in the direction of growth-lines, on a light ground. This pattern is common to many species of various genera of the family, and to some species in practically all the minor groups. It is one of the common patterns of coloration of snails in many families to have the pigment thus deposited periodically instead of continuously. In many Partulinas the streaks have become distinctly defined, and lose their primitive relation to the growth-lines, becoming zigzag or oblique, or they may be interrupted to form a tessel-

lated, marbled or mottled pattern. This is a line of pattern evolution peculiar to *Partulina*, at its acme in such species as *P. proxima* and the Perdicellas, decadent in many Partulinas and Newcombias.

In *Achatinella* the streaks, when present, are not sharply defined and always run in harmony with growth-lines.

The spiral bands of *Achatinellidæ* belong to *two band-systems,* entirely separate in inheritance. The genesis of the *irregularly placed bands* is readily traceable in existing species, but the origin of those of the *four-band pattern* is unknown.

Irregularly placed bands.—Many species which have spiral bands in the adult stage, are streaked when young. The several stages from the streaked to the banded pattern characterize various races or species; so that it appears likely that the continuous-banded pattern was never produced by a single mutation from the streaked, but by a series of progressive or orthogenetic mutations. The sequence seems to be somewhat thus:

(*a*) longitudinally streaked (pl. 60, figs. 4*a*-4*c*).

(*b*) streaks cut by light spiral lines or bands, leaving streaked zones or spotted spiral lines (pl. 60, f. 6; pl. 56, f. 5*b*).

(*c*) color of the dark zones or bands intensified or diffused, losing the streaked or spotted pattern (pl. 56, f. 5*e*, 5*f*).

Many individuals are intermediate between *a* and *b*, or *b* and *c*. Often instead of several or many pale or white bands appearing, the upper half of each whorl loses the streaked pattern, leaving it on the portion below the periphery, producing a bicolored pattern of cuticle, as in pl. 57, figs. 2*b*, 15. This is merely a special modification of stages *b* or *c*.

Judging from its sporadic occurrence, albinism may appear as a mutation at any stage of pattern-evolution; melanism is perhaps more frequent in the later stages.

All stages from streaked to banded may be seen in some species, such as *Achatinella fulgens* and *Partulina redfieldi.* May species remain in the primitive stage, while in others only the terminal pattern is seen.

The zoned or many-banded patterns are a higher (more evolved) stage; the streaked are lower in the scale; but from the co-existence of all stages in many species, it appears that the evolution of one from the other is a rapid process.

The transition from longitudinal streaks to spiral bands in these shells is entirely analogous to the transition from longitudinal to transverse stripes in mammals. It is a common phenomenon in mollusks, and examples can readily be found in most faunas, exactly parallel to the process in *Achatinella*. *Cf. Drymæus, Amphidromus, Helicostyla.*

Spiral bands or lines, resulting from the evolution of stripes, as described above, are *indefinite and variable in number and position.*

The four-band pattern. — The black-brown bands, which stain the prismatic layer of the shell and often appear as spots on the lip, have perfectly definite positions in *Achatinellastrum, Bulimella,* and a few Partulinas, when they occur at all, and are evidently homologous throughout these groups. See plate 38. These bands are four in number: 1, subsutural; 2 and 3, above and below the periphery; and 4 around the columella. All are developed in pl. 38, figs. 4*a*, 6, 6*a*, 14. Often only bands 1 and 4 are developed, figs. 1, 1*a*, 2-4, etc. Other forms may have bands 2 and 3, or various other combinations. The bands of the four-banded or "tetratæniate" system may be expressed by a formula, such as is used for the five-banded or so-called pentatæniate Helices. Thus pl. 38, fig. 6 has the formula 1234. Fig. 7, 0000. Fig. 7*c*, 0230. Fig. 18*a*, 1(234). Fig. 19*c*, 1(23)0. In *Achatinellastrum* a particularly common formula is 1000. As in the pentatæniate Helices of Europe, the bands vary through the several possible combinations in presence or absence, and in width when present; they are sometimes split, or confluent; but *their positions are invariable.*

In inheritance, bands of this system are entirely independent of the variable or indefinitely-placed bands. They may exist in combination with any stage of the other pattern, from plain or streaked to many-banded; and even in melanistic shells they may be apparent as bands of slightly different luster, visible only in a certain light.

I have elsewhere noted that in *Liguus* some forms show an extremely interesting change in the pattern, whereby the dark and the light markings exchange places, as in a photographic negative, without other noticeable change in the shell. An entirely similar exchange is seen in some individuals of certain *Achatinellidæ*. Thus on plate 19, it will be seen that fig. 10 has the normal, tetratæniate pattern; fig. 5 is a "negative" of it, the black bands occupying the places of the white ones in the other shell. *A. crassidentata*, pl. 30, fig. 23, is a similar "negative" pattern. In *Partulina, P. porcellana* has the normal four-banded pattern, while *P. nattii* has the "negative" pattern.

The typical group of *Achatinella* (*Apex*) never has the four-banded pattern. This is one of the most important differences between this group on the one hand, and *Bulimella* and *Achatinellastrum* on the other.

Parallel and convergent evolution of patterns. — Since many species have forms with primitive streaked pattern and others with distinct bands, it appears that bands have many times been evolved independently. Occasionally this has resulted in the production of strikingly similar varieties as terminal evolution products of several species. Thus, *A. vittata simulans, A. turgida simulacrum* and *A. leucorraphe irwini* are superficially similar forms, which as their geographic distribution and the less evolved stages of some of them show, have descended from less similar streaked stocks.

In *Achatinellastrum* there are some forms of *A. cæsia* (belonging to the series of *A. livida*), which resemble forms of the series of *A. vulpina* so closely that some authors have actually united them specifically. Yet they inhabit opposite ends of the Main Range of Oahu, and their similarity is merely phenotypic.

Albino or melanic forms, belonging to different species or races, are sometimes practically identical phenotypically, when the differentiation in shape is slight or variable.

By the study of many colonies of a species, and of many species, in various stages of evolution, it appears that in all the genera of *Achatinellidæ* the evolution of color-pattern

has been orthogenetic. *Partulinæ* and *Achatinellæ* of many groups have followed the same path, beginning with streaked, leading to banded patterns. While the mutations of any one species may appear to be multifarious, it is clear that progress has been in the direction indicated. It is significant that the early neanic and (in *Partulina*) the late embryonic stages of banded forms often show the earlier streaked pattern.

Some forms of *Partulina* have taken another course, emphasizing the vertical markings; but in some of these (such as *P. helena, P. crassa*, Hawaiian Baldwinias etc.), there are forms which are evolving or have reached the banded stage.

The many-banded stage is the acme of pattern-evolution in *Achatinellidæ*. So far as we know, it is capable of no further modification except by decadence of pattern.

We may perhaps infer that the four-band pattern has been inherited from the ancestral stock of *Achatinella*. It is now present in many species of *Achatinellastrum* and *Bulimella*, and in some Mauian Partulinas. Sometimes it is represented by the "negative" or complementary pattern noticed on p. xxii, and very frequently it is imperfect, only part of the bands present, or all wanting. It seems thus to be decadent or in process of disappearing from the modern forms. There seems some ground for the hypothesis that in the present Achatinellid fauna we have evidence of two successive cycles of color-pattern.

(1) In the earlier cycle there were four dark color bands in definite positions. Of this pattern we see only the final stage, frequently in decadence, or perhaps remaining only as bands on the embryonic whorls. (2) The second cycle is now in the mid-stage of evolution from a streaked or axially striped pattern to one of many bands without definite arrangement. In the "Apex" group and some others, all traces of the four-band pattern has been lost; but in some Achatinellas and Partulinas it lingers on with a later pattern usually superposed upon it.

There seems to be no evidence that the axially striped *Partulinas* and their derivative groups, *Perdicella, Newcombia* and *Baldwinia*, ever had the four-banded pattern.

Shape and Structure of the Shell.

The *shape of the shell* has been varied much less in *Achatinellidæ* than in *Amastridæ*. Except in *Newcombia*, where the spiral has been conspicuously lengthened, the ovate or ovate-conic contour has been modified only in minor features. In *sculpture* the diversity is of degree. Nearly all species are polished, showing weak growth-lines and minute spirals, often descending obliquely, and frequently faint or absent on the later whorls. The later whorls of the embryonic shell are always minutely striate spirally. In *Partulina* the spiral striæ are often rather well developed; and in *Newcombia* they become prominent.

The axis of the shell is somewhat sinuous, and in the last whorl it bears a spiral lamella except in *Newcombia, Perdicella* and *Baldwinia*, where it is more or less degenerate. This lamella is progressively absorbed as the shell grows. In the embryonic stage it is represented only by a sinuation of the columella. In both *Achatinellidæ* and *Amastridæ* the forms lacking a columellar lamella are obviously not directly related, being terminal members of several evolutionary series. Thus *Perdicella, Newcombia* and *Baldwinia* have more direct affinity to *Partulina* than to one another. That the ancestral stock of *Achatinellidæ, Amastridæ* and *Tornatellinidæ* had a columellar lamella seems a fair inference.

Professor Hyatt's idea that *Partulina dubia* is a representative of the ancestral stock of *Partulina* seems to me inadmissible, as its weak columella is far more likely to be a recent degenerative character than a primitive heritage, and it has no other feature more primitive than other Partulinas.

The *direction of coil* of the shell and the dextral or sinistral disposition of the organs are unusually variable in *Achatinellidæ*; far less so in *Amastridæ*, where sinistrality is unusual, and in all cases a specific or group character. Many species of *Achatinellidæ* are invariably sinistral. In *Newcombia* all are sinistral. Other species are as invariably dextral. In such species a reversed specimen is as rare as among American land snails. A few species of *Partulina* and many of *Achatinella* are indifferently dextral and sinistral, either in

the same colony or less frequently in separate colonies. The direction of coil is hereditary as a general rule. I have never found a sinistral embryo in the uterus of a dextral mother. Mr. Thaanum, whose experience has been very wide, states that he has never taken both dextral and sinistral embryos from one mother, in the few species of *Partulina* which are indifferent in coil.

Frequently in adjacent colonies of the same race, sinistral shells may predominate in one, dextral in another. In other species, the prevalent direction of coil differs in different parts of its area. See *Partulina virgulata*, p. 358, *Achatinella vulpina*, and many other cases noted in the systematic part of this work. It seems likely that, as Mr. Gulick thought, dextral and sinistral snails find some mechanical difficulty in mating; but experimental evidence is needed.

The species conception in Achatinella.

The conception of "species" applied to *Achatinella* is involved in more than the usual difficulty. We have to do with evolution products of several grades, possibly of more than one kind.

Grade I.—Races having certain seemingly permanent associations of characters (though usually with other variable characters), and co-existing with allied races without forming hybrid colonies.

Grade II.—Geographic races (i. e. with a definite and consistent distribution), having moderately coherent associations of characters, but blending with other like races through hybrid or undifferentiated colonies where the geographic ranges meet.

Grade III.—Forms characterized by the possession of one or more special characters (usually of color), but which occur for the most part in hybrid colonies with other diverse forms; the characters seeming to be freely interchangeable, and occurring in different combinations, as in Mendelian hybrids.

The races included under (I) are *species* in the usual sense. It may be supposed that the specific isolation is physiologic. Thus, *Achatinella bellula* and *A. vulpina* are related species

occupying the same area without intergrading or hybrid forms.

Races included under (II) may be illustrated by the group composed of *Achatinella phæozona, fulgens, stewartii* and *vulpina*. By reference to the map on p. 183, it will be seen that the areas of these overlap slightly, but are in the main separate. At the points of contact there are transitional colonies which have every appearance of being hybrid groups, composed of individuals having various combinations of the characters of the adjacent races. It will readily be seen that the "species" of this grade do not have the same value as those of grade I, and *they might be more logically considered subspecies*. Such treatment of the section *Achatinellastrum* would reduce the species from 17 to 10, as explained on p. 181. In the genus *Achatinella* it has been thought more practical to recognize as "species" a certain number of races which admittedly intergrade at their limits, than to make the species conception so broad that no definite idea is conveyed. Moreover, the term subspecies is needed for subdivisions of lower grade. Thus the Koolau forms of *A. fulgens* show slight racial divergence, which is recognized by the term *A. fulgens versipellis*.

In *Achatinellastrum* and *Bulimella*, then, it is frankly admitted that the species of this work are groups of two grades, certainly differing widely in degree, quite likely differing in kind. Related forms which inhabit the same district without evidence of hybridizing may safely be put down as species of the first grade. In other forms, which may appear equally as distinct phenotypically, we find abundant evidence of hybridizing where their areas overlap; and these we rank as species of the second grade. How fundamental this distinction is in animals generally we do not know, and it has not yet been satisfactorily worked out from the experimental side. Practically the grade of any given form is to be decided in each case by field observations and abundant collections. On pages 119 and 181 the real or first grade species of *Bulimella* and *Achatinellastrum* are indicated. In the section *Achatinella s. str.* (*"Apex"*), the conditions are very complex.

The species of the *mustelina-decora* group, and those of the *apexfulva-leucorraphe* group (see p. 275 and diagram on p. 278) are certainly very closely related while *A. lorata* stands isolated. In *Partulina* most forms admitted as species seem to belong to the first grade.

Species and subspecies of all grades are usually composed of numerous color-forms of Grade III—that is, elementary patterns, which may rarely occur in pure colonies, but almost always in hybrid colonies comprising two or more patterns, in an almost endless variety of combinations.

What may be considered "fluctuating variations", that is, variations in the potency with which a pattern may be expressed, among individuals of a pure colony, are of great amplitude in *Achatinellidæ*. Thus, plate 60, figs. 17 to 17*c* may be presumed to be individuals having the same gametic constitution, but differing in the degree of potency of the factor controlling the deposition of pigment. Other examples are pl. 56, figs. 14 to 14*d*; 13 to 13*b*; figs. 1 to 1*c*. Most of the pure colonies show such variation in greater or less degree. Most shells having highly developed color-patterns show similar fluctuation. *Cf. Neritina, Liguus,* etc.

In a hybrid colony there is often almost perfect segregation of the color-patterns composing it, as in pl. 39, figs. 8 to 8*e*. This is usually the case where only two or three patterns are involved. Where the number is greater, the combinations become numerous. We are getting into the realm of trihybrids and multihybrids. Although we see only the phenotypes of the gigantic Mendelian experiment, it is our belief that with a good knowledge of the forms of any limited region, a trustworthy estimate of the elementary patterns present in a colony not too complex may be formed, though of course it would be absurd to say what the genotypic constitution of any individual of the colony might be.

The good segregation which prevails in hybrid colonies leads collectors to assort their shells. The strikingly diverse patterns were not unnaturally described as distinct species by European conchologists, who were ignorant of the facts of association. Moreover, before the Mendelian era, it seemed improbable that such diverse patterns could be hybrids.

From the results visible, it can hardly be doubted that the various components of color-pattern act as unit characters in inheritance.

In species covering an extended area, there is usually differentiation correllated with distribution. Thus in *A. fulgens* the *plumata* pattern, streaked in delicate tints, is a conspicuous form in Niu, the eastern limit of the species where green forms are not found (pl. 36, figs. 4 to 6*e*). Also in the next valley, Wailupe (pl. 36, figs. 3, 3*a*). Further west, in Waialae, the *plumata* pattern has become rare, though still present in various combinations, and green forms are common (pl. 37, figs. 1 to 6*b*). In Palolo, still westward, the green and yellow patterns are ascendant, and the *plumata* marking is hardly represented except in the *varia* combination. The ancient pattern of black bands in definite positions pervades the whole species, though the factor necessary for the appearance of these bands is often absent. Also albinos, doubtless genotypically various, as usual, appear sporadically throughout the range of the species.

This topic may be further illustrated by a diagram of the conditions found in *A. vulpina*. If we represent the various color-patterns (or "elementary species", at least in part) by their initials, the forms of the hybrid colonies of successive districts, from the east westward, may be represented thus

Pauoa	E. Nuuanu	W. Nuuanu	Kahauiki	Halawa	Waimano	Manana
a v c o	v c e o	o *v* l	o *v* s *a* l	o *v a* l	o *v*	*v*

(a, *adusta*; v, *vulpina*; c, *castanea*; e, *ernestina*; o, *olivacea*; *v*, *virens*; s, *suturalis*; *a*, *analoga*; l, *longispira*).

See also p. 215. The formulas could be made more complex by introducing various other characters. Thus, dextral individuals occur in the West, but are absent eastward. Moreover, several colonies represented by the same formula almost always differ in the relative numbers of individuals of the component patterns; and adjacent colonies, sometimes on a single tree or group of trees, may differ, some lacking patterns common in other colonies of the district.

Many of the "species" of Gulick are based upon colonies

in which a certain pattern or patterns predominated, though not to the entire exclusion of others. The same patterns may be present though uncommon in colonies a few miles removed, where other patterns take the leading role. Thus Gulick says of the special pattern he called *Apex tuberans*, "the metropolis of this species is Kalaikoa; it is also found in Ahonui, and single specimens have been brought from Wahiawa and Helemano." Any mutation having a recognizable pattern (races of the third grade) could be treated as a "species" by this method; and in fact there are numerous unnamed mutations neither more or less distinct than many of those which have been named and defined. It is often a convenience to have names for patterns in which the association of characters is moderately stable. We may speak of the *ernestina* pattern, the *dunkeri* pattern, etc., without committing ourselves for or against the theory that these names stand for races of systematic significance, or are in fact anything more than character combinations which from their abundance would seem to have a certain degree of cohesion.

A philosophic method of dealing with intraspecific differentiation is one of the greatest present needs of systematic zoology. Systematists can no more deal with species and subspecies as their ultimate units than physicists with molecules or even atoms. It is senseless to oppose the facts which our vaster collections and more critical methods are forcing upon us. The terms *species* and *subspecies*, though elastic, have a certain status recognized by those accustomed to deal with these matters, even though the categories may not be rigidly formulated. To enlarge the *species* conception to cover every group of individuals having a recognizable special character, as some naturalists have recently advocated, would be to reduce the whole subject to chaos. Some English naturalists give a special name to every form having a special character, such as albinism, xanthism, a special pattern, a particularity of shape, or the like. This is one method, doubtless far better than none, of making intelligible record of such matters. We are not prepared to name every *individual* of polymorphic species, but in reasonable limits it seems useful to have names

for groups of individuals having moderately coherent combinations of characters, and yet not properly to be ranked as subspecies. In this sense we have used such terms as "*olivacea* pattern"; "*dunkeri* pattern." In other cases we have avoided naming the forms, using numbers instead. The ideal (if impracticable) method would be to have a name or symbol for each unit character, and express the several combinations like a chemical formula; but although almost all the world is breeding animals or plants at present, it is not likely that we will ever have enough knowledge of unit characters to apply this method generally in nomenclature!

Color-pattern is usually independent of direction of coil of the shell, but in some cases, noted under various species, these characters are linked in inheritance. See under *Partulina virgulata*, p. 358, etc.

The facts indicate that mutations may appear anywhere in the area of a species, and spread from the initial point as far as time and conditions permit, mingling with the pre-existing forms of the species. The population is thus becoming constantly more complex. It occasionally happens that one comes upon what appears to be a mutation in an early stage of its career. Thus, near the foot of a small ridge in Popouwela, there is a large and prolific colony of *Achatinella mustelina* (pl. 63, figs. 10 to 10*c*). In the midst of this colony, in an area of two or three rods square, we found 20 or 30 pure white individuals, most of them immature. Not one was found in other parts of the colony, which three of us looked over pretty thoroughly, or in any other colony in the same district. The inference seems fair that the albino form had very recently arisen in that place.

Many cases of special color-forms known from single or very few trees are recorded in the descriptive part of this work. Some of these are doubtless remains of races once more widely spread, especially when they occur in decadent forest; but others we can hardly doubt, are new mutations. The collections made to-day very often show color-forms differing from those of the same valleys made sixty years ago;

but the comparison is vitiated by the uncertainty whether the same colonies were found. The older collections were not closely enough localized to afford evidence of progressive change. In many cases it is certain that they were from districts now deforested. The accurate record of colonies now kept by the best collectors will permit of such comparisons in the years to come, and if the snails are not exterminated, invaluable evidence for evolution will be available for Hawaiian students of fifty years hence, or even less. Answers may be found to such questions as the appearance of mutations, their influence on the colony and their fate, and the permanency or changes of hybrid and pure colonies under natural conditions, etcetera. In this connection, suggestive observations were made by Mr. Thaanum on a colony of *Partulina proxima*, revisited after an interval of twelve years. In the interval, an apparently new mutation—shells with pale greenish ground—had dispossessed the normal white-ground shells which alone were found twelve years before (see p. 360).

While there are good reasons for the belief that color mutations of considerable amplitude are common in *Achatinella*, it must be remembered that there is no actual evidence bearing on the production of species of the first grade, in other words, real species, by mutation.

Observations on the snails of many regions has led me to believe that the well-defined species are often, perhaps usually, rather complex populations of individuals differing in many minor but heritable characters, such as size, minutiæ of shape and sculpture, number of teeth on the radula etcetera. In *Achatinella*, as in *Liguus, Polymita, Amphidromus* etc., the versatile character is the very conspicuous one of *color*, and therefore has attracted far more notice than equally important but less noticeable characters in plainer snails.

One condition favoring intense speciation in the Hawaiian Islands is that the snails breed and grow all the year round. Hence, in a given time, their evolution should be at least twice as fast as that of snails in temperate latitudes, in which the organism is quiescent more than half of the time. This of course applies to humid regions in the tropics in general.

To the naturalist knowing these shells in the field, it would seem absurd to claim that the colors are *protective* in any ordinary sense, or that their evolution is controlled or directed by any sort of selection. It is perfectly obvious that one color or pattern is as good as another. A pattern predominating in one colony may be rare in the next, living under conditions apparently the same, and perhaps not half a mile distant. White shells, the most conspicuous of all to my eye, are as abundant as any others; though I would not give the impression that any *Achatinella* is very conspicuous. Mr. Perkins found no evidence that *Achatinellidæ* are ever eaten by birds, or in fact by any animal but the imported rats (Fauna Hawaiiensis I, vi, p. ccxxvi).

Weissmann's treatment of the subject of specific differentiation of Hawaiian snails does not appear to be based upon a sufficient knowledge of the facts. He considers the phenomena due to adaptive variation of species in a new environment.[1]

I have elsewhere expressed the opinion that the opaque coloring everywhere characterizing land shells living in exposed situations is an adaptation to exclude light. The corneous yellow, or light brown tints usual in ground snails are more translucent. The particular patterns evolved since arboreal life was assumed do not seem to affect the existence of the species. In common with Dr. Cooke and other observers, I have been unable to trace any constant relation between coloration and physical conditions (except as noted below), and there is certainly no connection between color and the species of tree inhabited.

In the typical group of *Achatinella* (*Apex*), a certain correlation seems to exist between the pattern and elevation, banded forms occupying higher situations than streaked forms of the same species, at least in many cases. I believe that the relation is an indirect one. Banded patterns have been evolved from streaked, as stated on p. xx; evolution in more humid stations would naturally be more rapid than in lower,

[1] The Evolution Theory, translation by J. A. Thomson and Margaret R. Thomson, London, 1904, II, 293–296.

less abundantly watered places, since resting periods would be shorter, and the succession of generations would be faster. I believe, therefore, that such forms as *A. turgida simulacrum, A. vittata simulans, A. leucorraphe irwini*, are accelerated races of species which at lower levels have lagged behind in pattern-evolution.

While many conchologists may consider the treatment of *Achatinella* in this work an extreme example of "lumping", (since we recognize but 43 species in place of 171 described), it really belongs to the splitting school. Both authors hold that a considerable further reduction would have to be made to make the species of equal value with most Oahuan species of *Leptachatina* or *Amastra*; that is, to make them all species of the first grade.

The immense color-differentiation of *Achatinella* has not been exaggerated by former naturalists, but its systematic value has been overrated. While it is believed that the "subspecies" of this work are in large part comparable to groups of equal rank elsewhere, the authors are prepared to find that some of them may turn out to be undeserving of a trinomial title. In other words, they may turn out to be forms of the third grade, like many of the species of Gulick.

Extent of specific areas.

An idea of the size of the specific areas of *Achatinella* may be gained from the maps on pp. 183 and 277 and the table on p. 276. The colonies of one species may be spread over from a dozen to fifty square miles, but actually occupy only a small per cent of the territory. Some color-races are known from very small areas—even down to one or two trees, as recorded in the text. In general, the specific areas in *Achatinella* are smaller than in *Amastra*, though there are exceptions. Some Amastras of the high peaks of the main range are as yet known from very limited areas. The species or races of the extremely humid region on top are generally of very limited distribution, but of course the summit of the main ridge is only known in spots, as there is no ridge trail.

Habits and Stations of Achatinellidæ.

Achatinellas are nocturnal as a rule. By day they sit dormant, usually attached by dried mucus, except in quite wet places. They are not firmly attached, like *Oxystyla* in dry weather, but securely enough to resist any but very violent shaking. Forms which frequent the trunk and limbs of trees often gather in crotches, in knotholes, or hide under loose edges of bark. Others stick on the leaves, particularly in the concave of a curled leaf. Often two or three roost in company; and when one is found alone, there is usually a companion not far away. Sometimes many gather in a commodious knothole.

Pubescent plants are avoided. Otherwise there seems to be little selection, any species living on a considerable number of plants. Dr. Cooke whose observations are recorded under *A. bellula multizonata*, was unable to trace any connection between color of snail and species of tree, and other observers have reached the same conclusion. Various introduced plants, particularly guava and lantana, are frequented by the snails.

In the axils of *ieie* one finds *Achatinella* in company with *Philonesia, Succinea* and *Auriculella*. It is a favorite station for *A. abbreviata* and *A. lila*, but is also frequented by many other species. This plant reminds one of the tropical American bromeliads, as in the humid zone water collects in the axils of the terminal bunches, deluging one as they are bent down.

The native bananas are good shell plants, both for *Achatinella* and *Laminella*. They grow in small clumps in humid ravines.

The *kukui* or candle-nut tree (*Aleurites moluccana*), so often mentioned by Mr. Gulick, occupies a broad zone on the lower mountain slopes. It is conspicuous from a distance by the very light green foliage. The tree is commonly rather rounded, with widely spreading, open limbs, branching much like our Floridan gumbolimbo.

While *Achatinella* ascends thirty feet or more, most collecting is from quite small trees and shrubs. The snails are hard to see on such copiously leaved shrubs as *mokihana* and the

like, and it takes some experience to find them. The eye must be trained. I have had good collectors follow me and say that the best collecting was on the trees I had looked over!

I have never seen an *Achatinella* crawling on the ground, though occasionally on returning over a trail, one finds shells which had been dislodged some time before. Mr. Spalding tells me that his experience is the same. See also pp. 99-102 for observations by Mr. Henshaw. These snails are certainly more inert than our American Helices, which if dropped usually make off promptly; yet it seems likely that by night they wake up. It seemed to me that the young shells wandered more widely than the adults. Certainly with us young snails walk more in the day time and wander more than old ones. In the head of Kamalo, Molokai, there was a forest of native trees, now all dead and prostrate, doubtless from the destruction of the undergrowth by cattle or deer. It is now covered with low lantana, standing in patches, groups or singly, and bearing a copious population of *Partulina redfieldi kamaloensis*. They are also on the dead trees. It does not seem likely that they could have spread so universally from the trees to the immigrant lantana without crawling on the ground for short distances. Observations with a lantern should be made in some such prolific colony. However this may be, it is evident that migration is slow, and probably for the greater part by way of the interlocking branches of adjacent trees. Where the vegetation is dense, there is often a pretty continuous highway; but the colonies of shells on isolated trees or small groups of shrubs must often be segregated from their fellows for many generations.

Mr. Perkins has mentioned a fact which I find is known to all Island collectors, that a species may be found on one tree or shrub, year after year, without spreading to neighboring shrubs. This is true also of some arboreal *Pupillidæ* and *Endodontidæ*. It strikes the outsider as uncanny to be taken to one certain tree to collect specimens of some snail which either has never been found anywhere else, or nowhere else in the neighborhood or district. To find that trees just as good all around are barren of specimens is always a surprise.

The presence of special color-patterns on single trees or small groups, in many instances, is an evidence of the slowness of migration, as well as of the facility attending the origin of varieties.

Food.—The frequent presence of living snails on trees long dead indicates that their food is cryptoganic. Moreover, the leaves show no traces of grazing. The feces of *Partulina confusa* examined by Mr. Henshaw were composed chiefly of remains of fungi or algæ (p. 103). The contents of stomachs of *Achatinella mustelina* and several other species, examined by Dr. A. Brown and myself, were recognized as fungi, often with shreds or fibres probably of bark, which remained undigested in the intestine.

Achatinellidæ breed at all times of year. In any catch one finds part of the individuals carrying embryos. The length of life of the individual is not known.

The native Hawaiians claim that the tree shells have a song, which they have fancifully supplied with words. Dr. Newcomb (P. Z. S. 1853, p. 129) and Dr. N. B. Emerson (Sacred Songs of the Hula, p. 121), and others have given versions of this song. Mr. Perkins believes it to be the chirping of crickets.

Brief notes on the topography and conditions of collecting may be useful to conchologists who have not visited these islands. Those interested in the subject should consult the Introduction of *Fauna Hawaiiensis* by Mr. R. C. L. Perkins.

The Achatinellæ are not shells of the valleys but of the ridges and upper ravines. The bottoms of the larger valleys often lie below the zone of requisite humidity. This is doubtless much more generally true now than before the valleys were so extensively deforested. Certainly at the present time the ridges and their slopes are the chief natural highways of the tree-snails, and the valleys are barriers, in varying degree, to the spread of species along the ranges.

Since it is the valleys and not the ridges which figure in topographic nomenclature, it follows that the usual locality records by valleys are often less definite than we would desire. For instance the locality "Nuuanu valley" might mean

either the northern or the southern slope, a matter of some importance, since the Nuuanu-Kalihi ridge is a faunal unit quite noticeably different from the Nuuanu-Pauoa ridge. The locality records of Gulick are usually by valleys. Newcomb generally named only the district, a far less definite indication.

Mr. Gulick has related to me that in making his rounds from one mission station to another, he would engage Kanakas to collect for him. His own collecting was mainly on the lower slopes, reached from the valleys, in the kukui tree belt. Much of this territory is now barren, by recession of the forest.

The relatively small number of land snails on the windward (*Koolau* or northern) side of the main range of Oahu is not due to its "rougher climate" as supposed by Professor Hyatt, but to the fact that the slopes are largely too precipitous to support forests,—often so steep that they are practically barren. From the summit of the main ridge, reached by a long climb up the southern slope, a gigantic *pali*, ribbed by erosion, drops beneath your feet nearly to sea level. Such vegetation as finds root-hold often cannot be reached further than a few rods down from the summit, where one ventures clinging to bushes for support. At the foot of the *pali* there is a talus-slope, often with kukui and other trees, but at this low level there are few tree-shells or none, under present conditions.

Where long butresses extend out upon the Koolau side, as in the Kailua region, and from Kahana northwestward, these conditions are modified in many places; and here the forests were, or still are, rich in tree-snails, though the woodland limits have retreated far within their old boundaries. Once forests with *Achatinellidæ* and *Endodontidæ* shaded the plains far seaward from the lovely peak of Kaneohe, where now dead shells may be picked up in plowed fields, or gathered out of "pockets" in the rocks. It has been the same in the northwest. Forest-snails are found in the sand-dunes of Kahuku, now far from where living tree-shells exist.

The poverty of the ocean side of the range is therefore due chiefly to the small area of forested slopes and ridges, owing to the colossal erosion of this side, and also to the prac-

tically complete destruction of primaeval forest on the lower levels.

The chief area of *Achatinella* is from the ridge down to about the 1000 ft. contour on the southern or Kona slope. The best published maps of Oahu give a wholly false idea of the topography of the western half of the Main Range. The fact is that the precipitation along the main mountain axis has formed great amphitheatres along the lee side. The ridges running westward or southwest from it are in part broken down, lowered, and worn to knife-like crests. Several miles further from the main axis, where erosion has been less potent, the ridges broaden out and branch, so that towards their lower ends there are more and wider high ridges than further up. Far down, finally, they may be cultivated on top. A map of this region, supplied by Mr. Spalding from his note books, is given on page 277, in order that an intelligent idea may be formed of the localities mentioned in the text for the western species.

In the Waianae range (see p. 341) the conditions are similar. Though it rises to a greater elevation than the Main range, it has also been more extensively eroded. Broad valleys, separated by knife-like or interrupted butresses, have been carved out on the southern (ocean) side, heading for the greater part in precipitous slopes, mostly inaccessible. There is a narrow fringe of forest, with tree-snails in places, around the heads of these valleys, but the major part of the slopes themselves are almost or quite barren, and too steep to support forest. The valleys of the inland side of the range head up so near those of the Ocean side in some places that only a narrow, wall-like arête remains, as above the heads of the Popouwela gulches. Standing on the wild-goat trail at the summit, a stone dislodged on either side might bound downward a thousand feet or more, so narrow is the ridge. At Waianae Pass the range has been almost gnawed through. Immediately west of this pass Mt. Kaala rises, the highest point on Oahu—huge, flat-topped,—its summit drenched by daily cloud or rain. West of Kaala the ridge narrows again. At the northwestern end of the range, where the foothills ap-

proach the ocean at and west of Kawaihapai, there is now no forest on top, but *Amastra, Leptachatina* etc. may be found on the wooded slopes. The chief forests of the range stand on the inland slopes and butresses from the top down to perhaps 1000 or 1500 feet. They are often prolific in Achatinellas of the *Mustelina* group. Several species of *Achatinellastrum* have also been found, but they are extremely local, and among the rarest Oahuan snails. *Amastra* and small shells are abundant.

The western half of Molokai is grass land, or barren where the country is broken, and there are no living land shells. The eastern half has the general structure of the main range of Oahu. Western Maui is similar, but here the gulches radiate from a central point. The Kohala region of Hawaii, like West Maui, is deeply cut by magnificent gorges, as seen from the sea. I regard it as one of the most important regions to be explored.

Lanai, which I did not visit, has a very limited amount of forest remaining, and this has been thoroughly worked by Mr. Thaanum. Important work is still to be done in the deposits of fossil shells.

While considerable climbing is involved in any serious collecting in the Hawaiian group, the altitudes are not great. In the Rocky Mountains our basal camps are usually above the tops of the Oahuan mountains, and the shell country goes up to over double the elevation. Yet the open, rocky slopes of our western mountains render them vastly more accessible than the Hawaiian mountains, where one does not think of making any considerable ascent unless there is a trail. I have gone through scrub oak thickets in Arizona as strenuous as any fern or ieie patches in Oahu, but they are exceptional, and can usually be avoided. In general, the slopes are more precipitous in the Islands, many more of them are practically inaccessible, and owing to the humid atmosphere and dense jungle, far less ground can be covered. Cross country tramps or short cuts are hardly thought of unless in a thoroughly known district.

To the collector who has worked in the West Indies, the

larger shells seem scarce and hard to find. Only small or minute shells are really abundant, and these only in spots. I would say that in Cuba, the same amount of work would result in at least ten times as many large shells as in Oahu, while the number of small ones would be about the same. In southern Arizona, one could not expect more "live" shells in a day's work than in Oahu or Molokai, if so many; and the number of species would be smaller. *Helicina, Succinea, Philonesia, Tornatellinidæ* and *Leptachatina* are usually rather abundant. *Pupillidæ* and *Endodonta* often abundant, but very much more local.

It is easy to understand the genesis of arboreal snails when one sees the conditions in such humid forests as those of Hawaii, where the rainfall totals one to two hundred inches. Snails of all kind—*Helicinidæ, Zonitidæ, Endodonts, Amastras, Pupillidæ* — wander freely over the herbage and tree-trunks. There is no need for them to stay close to the damp earth and under cover, as in dryer climates.

Achatinellas are usually cleaned by "squirting" without cooking. A small nozzle attached to a faucet gives a good stream for the purpose, or a syringe may be used. Hot water changes the green color to a dirty olive or brown. The chemical relations of green and brown must be very intimate. White shells or those with dull colors, like *Partulina, Amastra* and many others, may be boiled without detriment to the colors. As a rule, *Achatinellidæ, Amastridæ* and *Auriculella* pull easily. Living Achatinellas are daintily clean and bright; and of course no oil or anything else should be put on the shells to improve or preserve the colors.

The numerical preponderance of arboreal *Achatinellidæ* in the Island faunas has been much exaggerated. The actual number of species known is less than one hundred. The genera *Amastra* and *Leptachatina* both outnumber the tree shells. *Leptachatina* will eventually prove to be far the most prolific genus in the fauna, in the opinion of Dr. Cooke, who has given it special attention. Kauai and Maui will doubtless turn out many new species of *Amastridæ*, and in Maui, *Achatinellidæ* also. Hawaii — especially the Kona side — is

yet very imperfectly known. The spectacular gorges of the Kohala mountains appeal to me as a promising field. Moreover, it is an important point from the zoogeographic standpoint. On all the islands, the fossil beds promise good entertainment.

The snail fauna, outside of Achatinelloid forms, has been only imperfectly worked up, and many undescribed species are now known. We cannot doubt that a large number remains to be discovered. On the whole, it appears that the work to be done in faunistics alone is much more than one generation can accomplish.

Much in the preceding pages may seem trite to Hawaiian naturalists, accustomed from boyhood to scale the rugged, jungle-clad mountains of their exquisite islands in the quest of shells, or wild goats. I would not presume to write for them upon many topics which have been touched on here, in order that conchologists elsewhere may better understand the Hawaiian faunas.

Notes on the Zoogeography of Achatinelloid Snails.

(Supplemental to Vol. XXI, pp. xi-xix.)

Arguing from the distribution of the living snail fauna, the theory was advocated in Vol. XXI that the islands were formerly united, allowing land and fresh-water snails and other land animals and plants to pass from one to another. The exploitation of the deposits of fossil land shells lends effective support to this theory.

In the recent fauna, the *species* of Achatinellidæ and Amastridæ are special to each island, though in a few cases the difference between some species of two islands is small. In the Pleistocene fauna the relationship was closer. Oahu had a *Partulina* of Molokaian type (*A. montagui*). The *Amastra umbilicata* group is found to be common to everyone of the islands. *A. umbilicata* of Oahu and Molokai is barely distinguishable from *A. morticina* of Maui and Kahoolawe, and *A. ultima* of Hawaii is very closely related.

In *Leptachatina*, the group of forms having a posterior tubercle and groove in the aperture, formerly known only by

one specimen from Kauai (*L. fossilis*, Vol. XXI, p. 61), is now known from many beds on the north, west and south shores of Oahu, from Molokai, Maui, Kahoolawe and Hawaii. This group of *very closely related* forms, now extinct, was common to at least six of the islands in the Pleistocene. One species, *L. subcylindracea*, was common to Oahu, Molokai and Kahoolawe, and the forms of Maui and Hawaii are barely distinguishable. The extinct forms of the *L. oryza* group from Oahu to Hawaii are so very similar that we have doubts of their specific distinction.

Upon the hypothesis that the snails had been distributed by ocean drift, birds, etc., it would be expected that the number of species common to two or more islands would be increasing by the occasional action of such agencies. The fact is, that species common to two islands were more numerous in the Pleistocene than they are today, even though the exploitation of the fossil deposits has only begun, and the recent fauna has been studied for years. Such a condition is exactly what we would expect if the islands had been united in the late Tertiary, and their common faunal elements had been distributed by known and normal modes.

The hypothesis that *Achatinellidæ* (or rather *Amastridæ*) first come to Kauai, and thence to the other islands, as advocated by Professor Hyatt (p. 371 *et seq.*) no doubt had its inception in the orthodox view of the relative geologic age of the islands. The biological evidence relied upon by Hyatt has proved, now that the fauna is more fully known, to indicate no such succession of faunas. Taking the fossil species now known into the account, it becomes obvious that all the islands have, or in the Pleistocene had, very closely related faunas of the primitive groups: *Leptachatina* (certainly the most primitive genus of the family), *Amastrella*, *Cyclamastra*. Between these closely related species it would be absurd to claim that those of Kauai are more primitive than those of Hawaii, or any other island. The same evolutionary stage is equally represented by species on all the islands. Hence, it seems likely that these common faunal elements remain from a former time when the islands were

united. In addition to these primitive *Amastridæ*, almost every non-Achatinellid genus of land and fresh water shell found in the archipelago occurs on all the islands, excepting the low and arid Niihau and Kahoolawe, where part are wanting. It appears highly improbable that so many genera should have become so generally diffused by any "accidental" means of over-sea transportation. That Kauai has ever contributed faunally to the other islands by means of drifting trees or the like is the more improbable because such drift would be against what current there is, and directly across the course of the trades. The snail fauna of Kauai is "primitive" only in lacking representatives of the *Achatinellidæ*, and the arboreal genus *Auriculella*. The fauna of *Amastridæ* and other families is on a par with the faunas of the other islands. The absence of *Achatinellidæ* from Kauai seems to be a rather strong argument, albeit negative, against the view that the fauna of the entire group emanated from Kauai.

Mr. Perkins, in discussing the dispersal of *Achatinellidæ* states that "once, on Molokai, a young living *Achatinella* was found attached to the feathers of the Drepanid bird *Chlorodrepanis*. Frequently they become adherent to one's clothes when passing through the brush. Doubtless in high winds very young shells are sometimes carried to a distance in curled up leaves in which they hide" (Fauna Hawaiiensis, Introduction, p. lxvi). While such means of travel must have had some part in the distribution of *Achatinella*, we are inclined to believe it a small part, for the reason that anomalies in distribution are very rare. If birds had carried the snails about, there would be colonies of "erratics," like granite boulders in a glaciated limestone region, instead of the thoroughly *consistent* distribution which is the rule on every island.

It is now known that the family *Achatinellidæ* differs in important structural characters from the *Amastridæ*. While the two are allied, their separation must, if we judge by the analogy of other groups of known age, date back to the early Tertiary at least. Indeed I believe that no existing genus of

Amastridæ could have been ancestral to the *Achatinellidæ*. The points of agreement between *Kauaia* and *Achatinella phæozona*, noted by Hyatt (pp. 398-9), pertain to shell characters of little or no phylogenetic significance, and leave the important anatomical differences absolutely untouched. In fact I have failed to find any characters in *A. phæozona* which indicate it as an ancestor even of the species immediately related—far less of the whole Oahuan genus *Achatinella*!

The absence of arboreal *Achatinellidæ* from Kauai has provoked comment because the forests seem well adapted to tree shells. It is a grave difficulty from any point of view. I am informed that *Achatinella* introduced there thrives. Several hypotheses may be formulated. (1) It is possible that the *Achatinellidæ* reached the region later than *Amastridæ*, and after Kauai had been isolated from the remainder. This seems the simplest explanation. (2) *Achatinellidæ* may have existed on Kauai, but become extinct from some unknown cause, as the horse family in America became extinct. Or (3), it is possible that the events attending the submergence of the old Hawaiian land did not allow tree snails an opportunity to gain access to the new forests on the Kauaian volcanos. However this may be, speculation upon a negative character of this kind seems rather unprofitable employment in the present condition of our knowledge.

In my opinion there is no evidence whatever indicating southeastern Oahu as the point of divergence of the snails of that island. The geological features and the distribution of species are both too "mature" to indicate one place more than another in the Main Range as the initial point. In Hawaii both the geological structure and the distribution of *Achatinellidæ* point to the Kohala mountains as the area from which land snails have radiated. Species and varieties progressively diminish from this region down the east and west coasts.

From studies on *Amastridæ* (Vol. XXI) I concluded that the Waianae fauna had been independent of that of Koolau from the early period when all the islands were connected until late Pliocene or more likely Pleistocene. The tree shells

fully support this conclusion. There are five species of Achatinella, one Partulina and two Laminellas. Three of these are referable to Koolau species, and the others are so clearly allied to several diverse species, belonging to groups widely spread in the Koolau range, that they must be derivatives from them. There is no endemic Waianaean strain of *Achatinellidæ*, and from all indications it seems that this family was lacking there until Pleistocene time. The old Kaala massif, like Kauai, had a fauna of *Amastridæ*. In the diagram no. 2, in Vol. XXI, p. xx, Kaala might better have been isolated from the Oahu-Hawaii island. These conclusions have support from the distribution of plants. Mr. Charles N. Forbes states of Kaala and its range that "its flora is as distinct from the main range of Oahu as is the flora of any separate island of the group" (Occ. Pap. B. P. B. Mus. V, no. 4, p. 13, 1913).

In the case of Maui, the two mountain masses are now separated by a considerable width of low land, impassible for land snails. It seems certain that the connection was formerly more intimate. The number of identical or very closely related species is quite considerable, and judging from Mr. Thaanum's last expedition, it is likely to increase. The isthmus must have been densely wooded, and probably it stood at a decidedly greater elevation, to permit free exchange of mountain snails. A rather recent subsidence of the whole island is indicated by the absence of such an extensive peneplain as would result from the tremendous erosion of West Maui, if that had been accomplished at the present level of the island.

The Kauaian satellite island Niihau will doubtless prove to have had all of the widely spread genera of Kauai—such as *Leptachatina, Succinea, Helicina, Tornatellina, Pupillidæ, Endodontidæ* etc.—when its Pleistocene deposits are examined. A general account of the island and list of the plants has been given by Mr. C. N. Forbes from notes made by Mr. J. F. G. Stokes (Occ. Pap. B. P. B. Mus. V, no. 3 with map).

Theories relating to the origin of the Hawaiian fauna have been unduly influenced by the inferences of geologists con-

cerning the growth and history of the islands, especially as to their relative age, and the idea that they were built up from the sea bottom solely from materials ejected by the volcanoes. This hypothesis presumes an enormous output and a duration very long for the active life of a volcano. Nowhere on land, where the geologic structure is accessible, has any mass even remotely comparable in magnitude to the Hawaiian ridge been piled up by purely volcanic agency. While it is true that most volcanoes rise from low levels, it is also noteworthy that those whose summits stand high (18,000 to 30,000 feet above the general level of the supporting sea bottom, in the case of the Hawaiian ridge) are borne on the backs of great folded mountain uplifts, as the Andes, or the Mexican plateau. Since none of the known volcanic deposits are believed to be older than tertiary the hypothesis also limits the time available for the evolution of the peculiar Hawaiian fauna to a period far shorter than experience has shown is probable. Elsewhere we know that many groups of generic rank in the land shells go back to the Oligocene and some to the Eocene. The differentiation of the modern families must therefore have taken place largely in the Mesozoic. It is not likely that so strongly characterized a family as the *Achatinellidæ* is much later. The case would be different if *Achatinellidæ* were known to have existed on any of the continents, for then it might be claimed that they had drifted to the islands. Personally, I think the drift hypothesis, applied to these remote islands, is about as credible as the idea that life was first brought to earth on a meteorite. I can conceive that wood-boring beetles might travel in the logs from America which I have seen thrown upon the windward coast of Molokai—logs stripped of bark and worn deep into the solid wood by the buffeting of the waves—but my faith is too weak to believe that any snail could get deep enough in the wood to make the journey of two thousand miles dry, or that if it did, it would ever get out when the log finally dried on a tropical beach. Only arm-chair zoogeographers can hold to the hypothesis that the land snails, *Lymnæidæ* and *Melaniidæ* of these islands were

brought there by drifting logs, or sticking to the feet or feathers of birds.

We have to account for the presence of representatives of eight families of land and three of fresh-water snails.[1] There must have been at least sixteen, probably more, original immigrants. The affinities of practically all are with Polynesia, and much more remotely with the western border of the Pacific, *in no case with America.* Under present conditions, drift material can come only from America. This has certainly been the case during the duration of the present islands, as their coast topography shows. In all probability the trades have blown and the current flowed as they do now, since early geologic times.

The idea that the mollusks were carried by wind, as some insects and seeds may have been, is hardly to be entertained. The distance is too great.

The hypothesis that the Hawaiian volcanoes rise from a preexisting mid-Pacific ridge, now lost by subsidence, gives room in time and space for the development of the peculiar fauna. The tertiary history of the islands, on this hypothesis, has been mainly one of subsidence along with volcanic upbuilding. This subsidence has continued down to comparatively recent times. Such topographic forms as Pearl Harbor, Kaneohe Bay, Kahana Bay, can hardly be explained except as valleys of subaerial erosion. On the northern coast of Kahoolawe it may be noticed that the ravines and ridges extend out into the sea in a succession of little bays and points, although the present erosive action tends to wear away the points and silt up the bays.

There is also, as many authors have noted, conclusive evidence that on Oahu there has been a small Pleistocene elevation. This certainly amounted to 20 ft., as beds containing recent marine shells indicate. According to Professor Hitchcock, the bluffs at Kahuku are of marine origin up to 60 ft.,

[1] The following groups, now well established, are regarded as introduced in the human period: *Limacidæ*, *Philomycidæ*, *Helicidæ*, *Opeas*, *Cœcilioides*, *Planorbis*, *Viviparus* and probably *Ancylus* and *Musculium*.

above which they are consolidated dune formation. Some of these elevated beds have been referred to by Doctor Dall as Pliocene. This determination was not based upon actual determinations of fossils, but, I gather, from general considerations. My collections of marine fossils around Pearl Harbor and east of Diamond Head show only recent species, and lend no support to the idea that the raised beds are older than Pleistocene.

The "raised reefs" I had opportunity to examine in western Molokai are consolidated calcareous sand. They are dune deposits, as the irregular bedding clearly shows, although they often contain sea shells, blown up from the shore. Not much dependence is to be placed upon Hawaiian geology seen from a steamer's deck. Upon the whole, it appears that in Oahu there has been a very recent elevation, following a subsidence of far greater amplitude.

A good summary of the physiography and geology may be found in the earlier chapters of *Hawaii and its Volcanoes,* by Dr. Charles H. Hitchcock, Honolulu, 1909.

Age of the land-shell beds.

In the Islands the distinction between Pleistocene and Holocene deposits is a real and necessary one, since human occupation brought in factors profoundly affecting the physiography of the whole lower zone, or on some islands the entire area. It would also be inexact to call the Holocene beds "recent", though some of them are apparently of no great antiquity. If the terms are used loosely in this book it is because not enough work has been done to fix the age of the various dune deposits definitely. The Manoa, Kailua and Kahuku bluff deposits, and the beds of Mana, Hawaii, seem to be undoubtedly Holocene. The dune-covered beds of northwestern Oahu, those of Moomomi, Molokai, and those of the neck of Maui (which I have not seen), are doubtless older than the first group, but may possibly belong also to the early human period. The human remains in the Moomomi dunes, however, are probably intrusive. The land shell breccia and tuff of Diamond Head and other tuff cones of the Kona side of Oahu, are undoubtedly Pleistocene.

As yet, only the *Achatinellidæ* and *Amastridæ* of all these beds have been thoroughly studied, and these are the groups which everywhere show the greatest local speciation, therefore less useful for comparative studies of the beds than the widely distributed small shells of other families.

The Diamond Head breccia contains a considerable number of extinct species. Dune sand, *interbedded with land-shell breccia*, where the section has been fully exposed in the sand quarry along the road, contains only recent marine shells. I conclude therefore that the Diamond Head and Punchbowl land-shell deposits are Pleistocene, not Pliocene. A certain proportion of special species would naturally be expected in a region of such intense local endemicity as Oahu. They are not of themselves an indication of age.

Whether any fossiliferous deposits older than Pleistocene will be found on Oahu is doubtful. There is a possibility of inland deposits, but if the movement of the island has been mainly downward, as I believe, there is little probability that marine Tertiary beds will be found near the surface.

Recent Climatic change.

That there has been a change from more humid to dryer climate in many districts of all the islands, if not known by historic evidences would be demonstrated by the restriction of most land snails to higher levels than formerly occupied. Sixty years ago the Achatinellas were found in abundance at half the elevations now inhabited by them. Still earlier forest shells lived within a few feet of the present sea level, as the Kailua and Kahuku deposits show. Forest shells, *Amastra* and others, are found in many of the low deposits, and it is obvious that the Pleistocene forests extended nearly or quite to the sea on the northern and western coasts of both Oahu and Molokai. The changes within the last century are held to be due to deforestation by cattle, which by destroying the underbrush cause the dessication of the forest humus, and prevent reproduction of the native trees. In Lanai the wild goats have almost, and in Kahoolawe have totally, completed the destruction of native forests. With

loss of the forest there is less precipitation on the heated soil, and what water falls is not conserved. Whether the earlier destruction of low-lying forest was due to human agency is not known, but in the absence of any other known cause that seems likely.

The change from humid to arid conditions in the lower zone seems to have been too rapid to admit of the evolution of many arid country species. There is one *Succinea* which lives under volcanic rocks in the most arid places; a species of *Bifidaria* is often found in dry country, and a few Leptachatinas exist in similar places. In general however, one finds little or nothing to encourage search on the slopes of the lower zone.

The same tale of increasing aridity is heard from the tuff cones of the Kona coast, where deposits of fossil forest-snails occur on Koko Head, Diamond Head, Punchbowl, and others. These desolate cones, furrowed with gullies, chill the traveller approaching Honolulu with their austerity. Of herbage there is now little, save for a thin line of dusty algarobas (*Prosopis*) bordering the shore and straggling up the gulleys, and tufts of dry grass which may harbor the dry country *Succinea* and *Bifidaria*. In Pleistocene times, between periods of activity and after the eruptions ceased, these cones were heavily wooded, with a copious snail fauna. *Amastra, Leptachatina, Tornatellinidæ, Lyropupa* and *Nesopupa, Endodonta* and *Nesophila, Zonitidæ*, etc. found congenial environment, if we may judge by the abundance of individuals.

Notes on the synonymy of Achatinellidæ.

The specific synonymy of *Achatinellidæ* has been discussed by Pfeiffer in the various volumes of the *Monographia Heliceorum*, by Newcomb (1858), Dr. W. D. Hartman (1888), D. D. Baldwin (1893) and Mr. E. R. Sykes (1900), all of whom have given synonymic lists of the species known to them. Messrs. Gulick and Thwing have also made suggestions. While the synonymy of the present work differs widely from previous arrangements, it has not been thought desirable to occupy space with criticism of the views of other

authors, except when occasionally some felicitous grouping by one or another student inspired approving comment.

It would be quite impossible for an investigator knowing these shells only by small museum series, already assorted, and often imperfectly localized, to arrive at right conclusions. Several factors combine to render the recognition of species and races unusually arduous in *Achatinella*. The absence of differentiation in structural characters is the chief hardship. In any allied series the shape is about the same, and the size is remarkably uniform throughout the genus. There are no such extremes of size as in *Partulina*. Both shape and size vary so much individually and with locality that they cannot often be depended upon to separate allied species, except in the average. There is very rarely any specific sculptural modification; and finally, the color and pattern are kalaidoscopic in many races, and a special pattern is often produced orthogenetically in several species.

Any polychromatic species is likely to produce individuals of strange or unusual patterns, sometimes possibly as new mutations, more often as a result of some unusual combination of color-factors in complex hybrid colonies. Such unique or exceptional individuals may readily enough be referred to their proper species if kept with their associates in life; but separated from their colonies, and without definite locality, it is sometimes almost or quite impossible to tell what racial stock they belong to. A number of the species described by Dr. Pfeiffer from specimens sent by Mr. Frick were evidently such exceptional, or as they say, "freak" shells. Any large collection contains shells which, if isolated and described without locality, could be referred to their proper species only with the greatest difficulty if at all.

A further source of perplexity is the tendency of some species to form melanistic or albinistic mutations. In the absence of structural characters, such forms, when not accompanied by their associates, and especially if without exact locality, may be difficult or even impossible to refer to their proper species or race. This is particularly true of the *Apex* or typical group of *Achatinella*.

Dissections of a considerable number of species indicate that the soft anatomy shows even less specific differentiation than the shells. Further work along this line should be done; but my impression is that very little assistance is to be expected from the soft parts in distinguishing closely related species of *Achatinella*. I did not have time to test the value of body or mantle color as a specific character. It is not likely to be more constant than shell color.

Finally, we have to do with artifacts. Newcomb, Gulick and others have commented upon the manufacture of "new species" of *Achatinella*, practised by some persons. These individuals were not actuated by a desire to advance science. They were moved by cupidity, or a perverted sense of humor. Perhaps all of the old collections contain some of these altered or "improved" shells. The commonest alteration is a change of hue by the use of hot water. Other patterns were altered by scraping the very thin colored cuticle, sometimes adding bands with colored ink, as in pl. 30, figs. 48, 48*a*, 51, 52. An ingenious method practised years ago, which Dr. Cooke obtained from an old resident of Honolulu, was to glue thread around the suture or elsewhere, and hold the shell in the smoke of a whale oil lamp. When the thread was soaked off, some weird color-effects were produced.

The synonymy of *Partulina* is less involved than that of *Achatinella*. The species differ much more in shape and size, and are less variable in color and pattern. In other words, there has been much more speciation. Moreover, the shells have been collected less. Probably when Maui is more fully explored some of the accepted species will be found to intergrade. The *Amastridæ* present no special problems in the distinction of species. They are not more or less difficult than ground-shells of other parts of the world.

Historical notes on the literature.

I.

The first Achatinellid shells brought to Europe, so far as we know, were obtained by Captain George Dixon, who visited the Hawaiian Islands in 1786 and 1787. They were strung

on a *lei* or necklace, which seems to have been made entirely of *Achatinella apexfulva* and *A. decora.* It appears that four specific names were based upon these specimens. The shell described by Chemnitz as *Turbo lugubris* was doubtless from the same *lei.* It was purchased in London by Spengler. While the source of Lamarck's *Monodonta seminigra* is not positively known (Delessert ascribing it to Captain Cook), yet very likely it also was from Captain Dixon's *lei.* There is no satisfactory evidence that Captain Cook's expedition brought back any *Achatinellidæ.*

The French corvettes *Uranie* and *Physicienne* visited the Hawaiian group in 1819. They obtained 14 species of land shells, which were worked up by Férussac, at that time the foremost authority on land shells. These shells were from at least two sources: *A. decora, lugubris* and *spirizona* were probably from a *lei* made in the Kawailoa-Helemano district, in western Oahu. *A. luteola* has not been rediscovered. I formerly thought it might be from the western slope of Hawaii (Vol. XXI, pp. 321-2), but the little I could see of that arid coast from the steamer's deck does not favor such a theory. *A. vulpina, gravida, lorata, turritella, ventulus, textilis, tristis, auricula* were collected near Honolulu; according to Dr. C. M. Cooke, probably in Pauoa valley, where the same association still exists, by members of the expedition, perhaps in course of an ascent of Mt. Tantalus. *Endodonta lamellosa* and *contorta* were probably from the same neighborhood. The latter is said to have been found on ferns, a somewhat unusual station; neither has yet been quite satisfactorily identified.

The first American work on the genus was published by Jacob Green in 1827, when *Achatina stewartii* was described and figured. It was collected by C. S. Stewart, an American missionary who spent the years 1823-5 in Oahu.

The voyage of Captain Byron in H. M. S. *Blonde,* 1824-5 supplied the progressive English naturalist William Swainson with several fine species from the Kawailoa-Helemano district, where the stringing of shell *leis* or necklaces seems to have been carried on extensively. From the study of these

shells Swainson in 1828 erected the genus *Achatinella*, with the following species: *A. pica, perversa, livida, bulimoides, rosea, pulcherrima* and *acuta*. The type of *Helix byronii* Wood was also from the same source.

In 1845 Dr. J. W. Mighels described twelve species of *Achatinellidæ* and many other Hawaiian shells, and in the same year Dr. A. A. Gould published seven species, collected by the Wilkes Exploring Expedition.

In the Proceedings of the Zoological Society of London for 1845, p. 89, Doctor L. Pfeiffer offered some remarks on *Achatinella,* which he here for the first time adopted as a genus. He enumerated 18 species, described by Chemnitz, Férussac, Swainson and himself. A few additional species were described in the following year, all from the Cuming collection.

The monograph in *Conchologia Iconica* by Lovell Reeve, published in April-May, 1850, brought the subject fairly up to date. It was marred by erroneous identifications of some of the earlier species, which were a source of error for many years. 45 species are admitted and figured, 15 being described as new from the Cuming collection; about half of which are still considered valid. Some of the Cumingian shells were received from Mighels; others were doubtless from Thomas Nuttall, who collected plants and shells in the Islands, and who is known to have contributed Hawaiian marine shells to Cuming's collection. The figures of Reeve's monograph are beautifully drawn and lithographed and well colored in the original edition, but in separate copies of the monograph I have seen the lithographs are coarse (from improper removal of the varnish put on the stones to preserve the drawings), and the coloring is crude.

II.

In the decade 1850-1860 the subject passed largely into the hands of Hawaiian Americans. It was the era of the discovery and definition of species. The quantity of work along these lines accomplished in five or six years is marvellous.

Dr. Wesley Newcomb, a physician-naturalist from New York, collected extensively in Oahu about 1850-55; also in Molokai and Lanai. His two chief papers, published in 1853-4, more than doubled the number of species known. Newcomb was an excellent conchologist of the old school. Most of the forms defined by him are still held to be valid species or subspecies. He gave but little attention to small or critical species, and his localities are given by districts or islands.

In 1854 Doctor Pfeiffer enumerated the species then known, 122 in number, and classified them in seven sections. The systematic classification of the group began with this sketch. Numerous species were described by Pfeiffer from this time to 1859, partly from specimens sent by Newcomb, but mainly from shells collected by Mr. Frick. Many of these species have proved difficult to recognize, and a large proportion of them are synonymous with the earlier species of Newcomb and others. This was no doubt due to the lack of adequate material. Mr. Frick evidently assorted his specimens shrewdly, to get the greatest number of "species", and many of the forms described by Dr. Pfeiffer were based upon one or two specimens of unusual color or shape. He gave no definite localities.

Frick himself published only one paper "Notes on Hawaiian terrestrial Conchology (Sandwich Islands' Monthly Magazine, I, May, 1856, pp. 137-140). He mentioned only one Achatinellid shell by name, *Achatinella gigantea*; but numerous MS. names were given by him, some of which were printed years later in Paetel's Catalogue, while others linger only in the traditions of Island collectors. Among conchologists, Frick's name is chiefly remembered for the difficulties ensuing from his ignorant and unscientific methods. He seems to have been an industrious collector.

Mr. G. S. Emerson began collecting Achatinellæ in the period of Newcomb and Gulick, and some of his finds were recorded by both of these authors. A variey of *A. livida* was named for him. Some time later, Mr. J. S. and Rev. O. P. Emerson carried on the work begun by their father. W. T.

Alexander, better known for his work in other directions, also contributed to Mr. Gulick's material.

John T. Gulick began collecting *Achatinellidæ* in 1850, at the age of 18. Most of his collecting was done between that time and 1853. His work differed from that preceding by the careful attention given to locality and food-plants of the snails. He was also the first to collect the small ground-shells, especially *Leptachatina*, extensively, as he was the first to appreciate their characters. Two descriptive papers were based upon this most comprehensive and valuable of all the early collections. The first was published in 1856; the second, in collaboration with Mr. E. A. Smith, not until 1873, though dealing with material collected in the early fifties.

Mr. Gulick's descriptive work, like his field work, was on a higher plane than that of his contemporaries. He sought to record the marvelous variation and differentiation of the island fauna. The suggestive geographic relations of allied forms made strong appeal to his imagination. One sees the same trend of thought in C. B. Adams' Jamaican papers of about the same date; and as everyone knows, Darwin had been deeply impressed by similar phenomena observed in the Galapagos.

Many of the species of Gulick are now given another interpretation or value; many have been confirmed by subsequent investigations. His classification of the group (P. Z. S. 1873) was a long stride forward, improving the arrangements of Pfeiffer and von Martens in important details. Though this work is concerned chiefly with systematics, allusion should be made to Gulick's greatest intellectual service, his theory of segregation in its several forms, as a necessary condition of the evolution of species, originally suggested by his studies on Oahuan Achatinellidæ. First stated in 1872, it was fully discussed in his "Evolution, Racial and Habitudinal, Washington, 1905.

W. H. Pease, whose occupation as a surveyor took him over Kauai and other islands, published several new species, and in 1869 a classification and catalogue of *Achatinellidæ*.

From 1855 on there seems to have been little scientific col-

lecting for about twenty-five years, and scarcely anything was published on *Achatinellidæ*, if we except the two papers by Gulick (1873), which belong properly with his earlier work.

III.

Several papers on the soft anatomy of *Achatinellidæ* by Wm. G. Binney and T. Bland, published in 1873-6, were important as showing that there are two radically diverse types of dentition in the group.

Mr. D. D. Baldwin and Mr. Thwing began their extensive collections about this time, and in the later eighties and first half of the next decade a number of younger men were enlisted, most of whom contributed new material for Mr. Baldwin's papers. Dr. C. M. Cooke's collection, which was studied by Professor Hyatt, and extensively used in this work, was begun at this time.

Dr. W. D. Hartman, whose material came from Newcomb, Pease and Baldwin, published a catalogue of the group in 1888. It was marred by many errors of all kinds.

Mr. D. D. Baldwin's papers, published from 1886 to 1908 were the most important expression of the work of this period, and stimulated the study of the fauna by local naturalists. His Catalogue of 1893 though modest in form, has been widely used and quoted on account of its reliability in classification and geographic distribution. His descriptive papers are lucid and well considered.

The *Mollusca* of *Fauna Hawaiiensis,* by Mr. E. R. Sykes, (1900), contains a useful synopsis of the group, and a bibliography of Hawaiian conchology.

The "Reprint of the original descriptions of the genus *Achatinella*" by Mr. E. W. Thwing (Occasional Papers Bishop Museum, 1907) has proved very useful to Hawaiian naturalists. The grouping of the species and the suggestions relative to synonymy involved a good deal of original work on the part of the compiler.

Herr Fr. Borcherding has published two profusely illustrated papers, *Achatinellen-Fauna der Sandwich-Insel Mol-*

okai, Zoologica, vol. 19, 1906, and *Monographie der auf der Sandwichinsel Kauai lebenden Molluskengattung Carelia,* Abh. Senck. Naturforsch. Ges. vol. 32, 1910. The first was based chiefly upon material collected by Mr. Meyer and his sons, purchased by Professor H. Schauinsland. It contains a lengthy history of the literature of Achatinellidæ and an excellent bibliography.

IV.

In the last six or eight years there has been a revival of interest among Hawaiian naturalists, and a number of large collections have been formed. The exact data preserved, the large series obtained from a great number of localities and the new localities exploited, give these collections great value, whether for systematic or for biometric investigations. Several papers by Dr. Cooke have been based upon this material, and it has also been utilized in these volumes. The few months spent by the senior author in the Islands did not permit anything more than a superficial study of these collections. Much of what value this work possesses is due to information derived from material brought together by the competent and enthusiastic Hawaiian naturalists of the present time.

Genus NEWCOMBIA Pfeiffer.

Newcombia Pfr., Malakozoologische Blätter, i, 1854, p. 117, for *A. helena*, *physa*, *ornata*, *cumingi*, *plicata*, *newcombiana*, *cerealis*, *elongata*.—Martens, Die Heliceen, 1860, p. 249 (type *A. plicata* Migh.)—Pease, P. Z. S., 1869, p. 649 (exclusive of Sect. 2).—Sykes, Fauna Hawaiiensis, p. 331.—Borcherding, Zoologica, xix, Heft 48[1], p. 94.—*Newcombiana* Thwing, Occas. Papers B. P. B. Museum, iii, no. 1, p. 138, 1907.

Shell oblong-turrited, usually coarsely sculptured, the embryonic shell of $3\frac{1}{8}$ whorls having comparatively coarse spirals (8 to 12 spirals on the second whorl), the last embryonic whorl longitudinally striped. Outer lip slightly expanded or not; columella straight or weakly folded.

Type *N. plicata* Migh. Distribution, Molokai and Maui.

Newcombia, by its distinct, minute, decurrent, spiral striation, and boldly striped last embryonic whorl, is clearly a specialized group of *Partulinæ*. It is here accepted as of generic value only by reason of its considerable secondary modification in sculpture and shape of the columella. Moreover those concerned with Hawaiian faunas now generally use the group as a genus. It is obviously not on a par, systematically, with the genera of *Amastrinæ*.

N. carinella is the only dextral species known.

Pfeiffer's list under *Newcombia* was heterogeneous, but contained several species (*cumingi*, *plicata* and *newcombiana*), now included in the genus. Professor Von Martens, in 1860, selected *A. plicata* as the type. His second section of the group contains species of *Laminella*. Pease, in his classification of 1869, associated species of *Heteramastra* with his Newcombias. These discrepant forms have been eliminated by Hartman (1888), Baldwin (1893), and subsequent authors.

The distribution of closely related forms on Molokai and Maui shows that the genus was developed in nearly its modern condition while these two islands formed a single area. It is somewhat peculiar that no Newcombia has yet been found on Lanai, and I anticipate the discovery of the genus there, either recent or as a fossil.

Key to Species of Newcombia.

a. Parietal wall making an angle with the columella, the latter having a low fold or twist.

b. Surface smooth to the eye, finely striate spirally under a lens. Molokai. *N. perkinsi*, no. 6.
N. philippiana, no. 5.

*b*¹. Surface spirally ribbed or coarsely striate, sinistral. Molokai.

c. Pale, the later whorls cream-colored; length 15 to 25 mm.

d. Spirals acute. *N. plicata*, no. 1.

*d*¹. Spirals rounded or subobsolete.
N. p. gemma, no. 1*a*.

*c*¹. Dark colored; length 12 to 18 mm.

d. Spirals acute. *N. canaliculata*, no. 2.

*d*¹. Spirals obtuse, base darker. *N. sulcata*, no. 3.

*b*². Surface with fine beaded spirals, a small carina at periphery; zigzag-striped, dark-colored, dextral. Maui.
N. carinella, no. 4.

*a*¹. Parietal wall continuous with the columella, which is not in the least folded. Sinistral.

b. Longitudinal folds coarse and strong, rude spirals running over them. Molokai. *N. pfeifferi*, no. 9.

*b*¹. Longitudinal folds weak or wanting.

c. Very weak folds crossed by spiral threads, the intervals of which are minutely wave-striolate spirally.
N. cumingi, no. 7.

*c*¹. Smoother; spiral threads weak or effaced, the minute wavy striolation well developed. Molokai.
N. cinnamomea, no. 8.

*c*². Wrinkled or puckered over spiral cords; no minute striolation. Molokai. *N. c. ualapuensis*, no. 8*a*.

Series of N. plicata.

1. N. PLICATA ('Mighels' Pfr.). Pl. 1, figs. 1, 2, 3, 6.

Shell sinistral, turrited, rather thin; sculptured with acute, elevated, spiral liræ and very fine longitudinal lines; brown-

whitish, spire elongate, the apex rather obtuse. Whorls 6, a little convex, those of the summit marbled with brown. Columellar fold obsolete. Aperture semioval; peristome unexpanded, acute. Length 15, diam. 6 mm.; aperture 6 x 3 mm. (*Pfr.*).

Molokai (Mighels in Cuming coll.): Kalae (Meyer); Moanui (Thaanum).

Achatinella plicata Mighels MS., Pfr., Monographia Hel. Viv., ii, p. 235 (1848).—Reeve, Conch. Icon., pl. 6, f. 44*a*, *b*. (1850).—Newcomb, Ann. Lyc. Nat. Hist. of N. Y., vi, 1858, p. 312.—Thwing, Reprint Orig. Descript. Achat., 1907, pl. 3, f. 11.—*Newcombia plicata* Migh., Borcherding Zoologica, p. 94, pl. 9, f. 1, 1*a*.—*Bulimus liratus* Pfr., P. Z. S., 1851, p. 261, under *B. newcombianus* Pfr. (1853), no description; new name for *plicata* 'Migh.' Pfr.

The shell is perforate. The apex is obtuse, rounded, smooth in the first half-whorl; then spirals begin above the suture at the end of 1½ whorls; then about 6 to 8 smooth, subequal spiral cords. On subsequent whorls the cords become more acute, and some interstitial threads appear. The growth-striæ become strongly developed and irregular. The third whorl is longitudinally striped with brown or pale olive, the rest of the whorls being uniform cream color. The peristome in fully adult shells is narrowly expanded and thickened within. Columella weakly sinuous, its edge dilated in a triangular white callus above.

Length 18, diam, 8.2 mm.; whorls 6.

Length 25, diam. 9 mm.; whorls 6⅓.

Newcomb described the animal as "rather shorter than the shell; tentacles at their origin closely approximating, short and strongly clubbed; bottom of foot, mantle, and posterior part light grey, entirely mottled with fine blüish dots. Motions at first sluggish and timid but soon becoming bold, rapid and gliding."

1*a*. N. plicata gemma (Pfeiffer). Pl. 1, figs. 7, 8, 10, 11.

Shell subimperforate, sinistral, oblong-turrite, rather solid, striatulate and spirally lirate (the liræ rather flattened, closely

sulcate), white; spire turrited, the apex rather acute; suture submarginate. Whorls 7, the upper ones flat, obsoletely variegated with brown; following whorls rather convex, the last about two-fifths the total length, somewhat carinated in the middle by a more acute cord. Columella lightly plicate. Aperture a little oblique, obauriform; peristome nearly simple; columellar margin subreflexed, a little expanded outwardly. Length 17, diam. 6.5, aperture 7 x 3 mm. Sandwich Is., Frick in Cuming coll. (*Pfr.*).

Molokai: Pohakupili (Baldwin); Halawa (Borcherding, for *N. costata*).

Achatinella gemma Pfr., Malak. Blätter iv, 1857, p. 230; Monographia iv, 560; P. Z. S., 1858, p. 22.—*Newcombia gemma* Pfr., Sykes, Fauna Hawaiiensis, p. 331.

Achatinella (*Newcombia*) *sulcata* Pfr., Baldwin, Catalogue, 1893, p. 8.—*Newcombia sulcata* Pfr., Gwatkin; Proc. A. N. S., Phila., 1895, p. 238 (dentition).—*Newcombia costata* Borcherding, Nachrbl. d. d. Malak. Gesell, 1901, p. 57; Zoologica, p. 95, pl. 9, f. 2, 2*a*.

The sculpture of the last whorl or two is more or less obsolete. This form occurs associated with more strongly lirate shells, in which the liræ are wider than in *plicata*, rounded, or more or less marked with spiral striæ. The *gemma* form is, in fact, only an extreme phase, with obtuse liræ, of this race, which has been called "*sulcata* Pfr." by Baldwin, and *costata* by Borcherding. The description of the latter follows:

Newcombia costata [pl. 1, figs. 4, 5, copied from Borcherding].

Shell subperforate, sinistral, turrited, rather solid; encircled with close, elevated liræ, more slender in the upper whorls, then more rounded, and sculptured with very fine longitudinal lines; last whorl with 7 rounded, flattened ribs above the middle, the ribs suddenly weaker below the middle, and becoming stronger again around the umbilicus. Color yellowish-white, glossy. Spire regularly tapering; apex rather obtuse; suture linear. Whorls 6, flatly convex, the upper flamed with yellow, the last forming half the total length, rounded. Aperture inversely ear-shaped, white within. Columella slightly folded,

white. Peristome expanded, with a white lip within; columellar margin recurved. Length 18, diam. 8, aperture 8 x 6 mm. Halawa, eastern Molokai (*Borcherding*).

In *N. p. gemma*, as in typical *plicata*, the liræ are variable in arrangement and number, no two specimens being quite alike. Figs. 8, 10, 11 represent typical *gemma*, while figs. 4, 5, 7 are the "*costata*" type, intermediate between *plicata* and *gemma*.

2. N. SULCATA (Pfeiffer). Pl. 2, figs. 9, 10; pl. 14, figs 9, 10, 11.

Shell subperforate, sinistral, oblong-turrited, rather solid striatulate, and encircled with close liræ, which are compressed in the upper whorls, then rounded; chestnut colored, somewhat shining. Spire regularly tapering, the apex rather acute; suture nearly simple. Whorls nearly 6, rather flat, the upper flamed with white, the last about two-fifths the length, the base saccate, of a deeper chestnut shade. Columella very lightly folded. Aperture oblique, acuminate-oval; peristome thin, the columellar margin dilated above, reflexed, outer margin a little expanded. Length $12\frac{1}{2}$, diam. $5\frac{2}{3}$ mm. Aperture $5\frac{2}{3}$ mm. long, $3\frac{1}{3}$ wide. Sandwich Is., Frick in Cuming coll. (*Pfr.*).

Molokai: Ahaina (D. Thaanum).

Achatinella sulcata PFR., Malak. Bl., iv, 1857, p. 231; Monographia, iv, 560; P. Z. S., 1858, p. 22.—*Newcombia sulcata* Pfr., SYKES, Fauna Hawaiiensis, p. 332.—BORCHERDING, Zoologica, p. 97, pl. 9, f. 4, 4*a*.—Not of Baldwin, Catalogue p. 8, or of Gwatkin, Proc. A. N. S.. Phila., 1895, p. 238 (radula).

"This species can be confused with no other. The whorls are regularly, obsoletely, transversely striate, increasing in strength to the last whorls and disappear on the lower half of the last whorl. The color is red-brown, becoming more intense with the increase of the whorls, and on the last whorl it is quite shining dark red-brown. The same analogy which exists between *plicata* and *costata* is here found between *canaliculata* and *sulcata*." (*Borcherding*, from specimens in the Hartman collection, probably received from Newcomb.)

Collectors of the present generation seem not to have found this species until it was taken by Mr. Thaanum at Ahaina.

The sculpture is most like that of *N. plicata gemma*, which differs by its much larger size and lighter color, *N. sulcata* having the last whorl rich chestnut colored, the next earlier whorl chestnut or reddish, and the preceding one flamed with white. The spiral cords of the last whorl vary in number and prominence. Specimens from Ahaina are drawn on pl. 14, figs. 9, 10, 11. Length 11, diam. 5 mm. The figures on plate 2 are copied from Borcherding.

3. N. CANALICULATA (Baldwin). Pl. 2, figs. 5, 6. 7.

"Shell sinistral, very minutely perforated, somewhat solid, acuminately turreted, apex subacute; surface sculptured throughout with numerous acute, spiral keels, which become blunter as they approach the apex, the interstices between the keels exhibiting under a lens very delicate growth striæ. Color brown, upper whorls tessellated with brown and white. Whorls 6, slightly convex, lower one somewhat flattened at the base; suture lightly impressed. Aperture oblique, oval, livid white or light brown within; peristome acute, very lightly thickened within, expanded, columellar margin reflexed over the small perforation, margined with light brown on both face and the reverse; columella very slightly developed, plain and smooth. Length 14, diam. 6½ mm.

"Animal when extended in motion as long as the shell. Mantle slate color, margined with brown. Foot light slate, studded on the sides and head above with spots of deeper shade. Tentacles short and slender, dark slate." (Baldwin.)

Molokai: Halawa (Baldwin); Punkolekole (Meyer).

Achatinella canaliculata BALDWIN, Proc. A. N. S., Phila., 1905, p. 226, pl. 10, f. 28, 29.—*Newcombia c.*, Bald., BORCHERDING, Zoologica, p. 96, pl. 9, f. 3, 3*a*.

Smaller and much darker than *N. plicata*, and with more strongly developed, more acute spiral ribs than *N. sulcata*. The spirals are at first equal and rounded, but become unequal and acute on the later whorls, with some smaller threads in most of the intervals, which are marked with growth-striæ. The color is red-brown, indistinctly streaked along growth-lines with whitish, the spirals also being whitish or pale at their summits.

The third whorl, or the second, third and fourth whorls are flamed with white. The figures represent cotypes. The largest shell in the type lot of 12 measures length 14, diam. 7.2 mm. The smallest is 13.3 mm. long.

3*a*. *N. c. wailauensis* n. subsp. Pl. 14, fig. 5.

Larger, more robust than *canaliculata*, lighter in color, the intervals between the spirals flesh-pink; spirals narrower. Whorls 6.

Length 17 to 17.5, diam. 8.7 mm.

Length 16.5, diam. 8 mm. (smallest).

Molokai: Wailau (D. Thaanum). Cotypes in coll. Bishop Museum and A. N. S. P.

4. N. CARINELLA Baldwin. Pl. 2, figs. 1, 2, 3.

The shell is dextral, minutely perforate, oblong-turrited, moderately solid; surface lusterless, sculptured with rather coarse and unequal folds and wrinkles along growth-lines, and numerous, minutely beaded spiral threads, 10 to 12 on the penult. whorl; on the last whorl the threads are smaller and closer below the acute peripheral keel; second and third whorls with many even, close, nearly smooth spiral threads. Marbled and zigzag-flamed with dark red-brown and white, the pattern becoming more confused on the later whorls; the smooth apex yellowish or fleshy. Aperture whitish or dark within. Peristome blunt, yellow at the slightly expanded edge, usually with a reddish submargin. Columella weakly folded, white, reflexed.

Length 14, diam. 7 mm.; $5\frac{1}{2}$ whorls.

Length 14, diam. 6.3 mm.; 6 whorls.

"Length 15, diam. 6.5 mm.; 6 whorls" (Baldwin).

East Maui: Nahiku (Baldwin).

Newcombia carinella BALDWIN, Nautilus, xix, April, 1906, p. 136.

A beautiful species, somewhat variable in contour and marking, but otherwise constant in a lot of 21 received from Mr. Baldwin. With the sculpture of *N. cumingi* it unites the shape of the *plicata* group, and is thus a connecting or synthetic form.

It differs from all other Newcombias by being dextral. Figured from cotypes.

Series of N. philippiana.

5. N. PHILIPPIANA (Pfeiffer).

Shell sinistral, subimperforate, fusiform-turrited, rather thin, longitudinally striate, decussated with somewhat wavy close spiral striæ; brown; spire slender, the apex rather acute; suture margined. Whorls 6, the upper flat, streaked with corneous and white, the last whorl more convex, about two-fifths the total length. Columella nearly simple, not folded. Aperture oblique, angularly semi-oval; peristome simple, unexpanded, the margins joined by a very thin callus, the outer margin bordered with brownish, columellar margin dilated above, subadnate. Length 15 to 15½, diam. 6 mm.; aperture 7 mm. long, 3 wide (*Pfr.*).

Var. *b*. Smaller, paler, a little more distinctly striated spirally (*Pfr.*).

Sandwich Islands (Frick, Cuming coll.).

Achatinella philippiana PFR., Malak. Bl., iv, 1857, p. 89; Monographia, iv, 559.—*Newcombia p.*, BORCHERDING, Zoologica, p. 103.

This species is known by the original examples only. Borcherding believes it to be an immature stage of *N. perkinsi* Sykes, basing this opinion on the smaller size and thin shell as described by Pfeiffer. This view, which seems quite probable, was held by Baldwin and Thwing; but until young *perkinsi* can be compared with the type of *philippiana*, and their identity demonstrated, both may be let stand.

6. N. PERKINSI Sykes. Pl. 7, figs. 18, 19.

"Shell sinistral, narrowly perforate, elongate-fusiform, solid, ashy-brown, or elegantly marked with zigzag streaks of brown. Spire slender, the apex obtuse, smooth. Whorls 6½, rather flat, the last about half the length of the shell; suture margined. Columella subplicate. Aperture a little oblique, semioval, subangular at the base; peristome simple, the columellar margin

dilated above, adnate. Length 25, diam. 7.5 mm.; alt. aperture 7.5, width 4 mm" (*Sykes*).

Molokai (Perkins, Hutchison): Makakupaia (Baldwin).

Newcombia perkinsi Sykes, Proc. Malac. Soc., London, ii, October, 1896, p. 130; Fauna Hawaiiensis, p. 332, pl. 11, f. 36, 1900.—Borcherding, Zoologica, p. 102, pl. 9, f. 6.—*Achatinella* (*Newcombia*) *philippiana* Pfr., Baldwin, Catalogue, p. 8.—Thwing, Reprint Orig. Descript. Achat., pl. 3, f. 10.

"Specimens are to be found in some collections under the name *N. philippiana* Pfr. The present species however is larger, much more solid, the whorls are flatter, the coloring is lighter and different, the columellar lip is more reflexed and the perforation more conspicuous" (*Sykes*).

In unworn shells there is a faint longitudinal ribbing after the smooth initial half whorl. Spiral striation sets in about the middle of the second whorl, and color-flames appear on the third whorl. The whole embryo consists of $3\frac{1}{2}$ whorls, the last one usually profusely marked with zigzag brown streaks, and more finely striate spirally than the other species. The post-embryonic stages have no major spirals, but under a strong lens are seen to be covered with a minute, irregular striolation, such as has been described for *N. cinnamomea*, etc. This sculpture is more or less effaced on the last whorl, often not discernible there, especially in individuals having weak longitudinal folds. The later whorls are mottled, marbled or streaked with white and flesh-color, and the last whorl often has a peripheral angle in front. The aperture is white within, with a brown lip-border. The columella has a long, low fold or twist, and makes an angle with the parietal wall, as in *N. plicata;* columellar reflection usually brown-tinted. Length 21, diam. 7.5 to 8 mm., $6\frac{1}{2}$ whorls.

This species is apparently the most primitive existing *Newcombia*, having no trace of coarse spirals on the whorls. The embryonic spirals also are finer than in other species, more as in *Perdicella*. The coloration too is rather that of *Perdicella*. *Cf. N. philippiana* Pfr., which is probably an immature stage of *perkinsi*.

Series of N. cumingi.

7. N. CUMINGI (Newcomb). Pl. 3, figs. 1 to 6.

Shell sinistral, acuminate, turrited, with strongly marked transversely oblique striæ and with longitudinal incremental striæ more or less developed. Color brown with undulations of white at the upper whorls. Whorls 5, flatly convex; suture moderately impressed, margined. Aperture oblong-ovate; columella slightly callous; outer lip thin, elliptical. Length .7, diam. .2 inch (*Newcomb*).

East Maui: Haleakala (Newc.). Makawao (Gulick, Baldwin). W. Maui: Wailuku (Gulick).

Achatinella cumingi NEWC., Ann. Lyc. N. H. of N. Y. vi, p. 25 (May, 1853); P. Z. S., 1853, p. 150, pl. 24, fig. 59 (1854).—PFR., Monographia iv, 559.—THWING, Reprint Orig. Descript. Achat., 1907, pl. 3, f. 12.

N. cumingi is imperforate. The embryonic shell of $3\frac{1}{2}$ whorls is spirally striate and flammulate as usual (pl. 2, fig. 13). The following whorls have nearly obsolete longitudinal folds crossed by crenulated spiral threads, usually coarsest in the peripheral region of the last whorl, finer on the base; the intervals minutely marked with spirally descending, wavy striæ (pl. 3, fig. 5, detail from back of last whorl, Wailuku specimen). Very often a peripheral thread is stronger, forming a low carina on the front of the last whorl. The surface is lusterless, dull brown. Aperture nearly white with a brown border within the thin, acute lip. The columella is long, straight, heavily white-calloused, and continuous in direction with the parietal wall.

Length 21, diam. 7.2 mm.; 6 whorls. From Newcomb.

Length 20, diam. 7 mm.; 6 whorls. Wailuku.

Length 19, diam. 6 mm.; 6 whorls. Wailuku.

The types were from East Maui, but I see no difference between those before me from Makawao (pl. 3, fig. 4) and the West-Mauian shells (Wailuku, pl. 3, figs. 1–3, 5).

8. N. CINNAMOMEA (Pfeiffer). Pl. 3, figs. 7 to 11; pl. 14, figs. 1 to 4.

Shell imperforate, sinistral, fusiform-turrited, rather solid,

opaque, longitudinally plicatulate, spirally sublirate and very lightly granulated, cinnamon colored. Spire long, somewhat rectilinear, the apex rather acute; suture nearly simple. Whorls 6, slightly convex, the upper marbled with brown and white, last whorl about two-fifths the total length, tapering and chestnut-colored below the middle. Columella simple, receding. Aperture slightly oblique, semioval, subangular at base; peristome simple, unexpanded, acute. Length 19, diam. 5, aperture $7\frac{2}{3}$ x 3 mm. Sandwich Is., Frick in Cuming coll. (*Pfr.*).

Molokai: Mapulehu (Baldwin, Thaanum); Makakupaia (Perkins, Meyer); Honomuni, Moanui, Kupeke and Ahaino (Thaanum).

Achatinella cinnamomea Pfr., Malak. Bl., iv, 1857, p. 230; Monographia, iv, 559; P. Z. S., 1858, p. 22.—*Newcombia cinnamomea* Pfr., Baldwin, Catalogue, p. 8.—Sykes, Fauna Hawaiiensis, p. 331.—*Newcombia cumingii* Newc. (in part), Borcherding, Zoologica, p. 99, pl. 9, f. 7 (Makakupaia).

This form resembles *N. cumingi* closely in shape and microscopic sculpture, but it differs by the weakness of the spiral cords, which vary from weak to almost effaced. As this differential feature seems to hold in considerable series of both forms, I think it best to retain the name *cinnamomea* for the Molokai race, although the relationship to the Mauaian *N. cumingi* is so close that perhaps *cinnamomea* might better be ranked as a subspecies.

On account of the weakness of the coarse sculpture, the minute, wavy, crenulated or granular striation (pl. 3, fig. 7) is more distinct in this race than in Mauian *cumingi*. The axis is often perforate. Immature shells are more strongly lirate than the adults, and often could not be distinguished from *N. cumingi*. *N. cinnamomea* is therefore to be viewed as a derivative of *cumingi*.

The fully formed embryo of $3\frac{1}{4}$ whorls, length 4.7 mm., has a very heavily calloused columellar fold, but no lamella (pl. 1, fig. 12). Younger embryos have the callus weaker, hardly noticeable in those of two whorls (pl. 1, fig. 9). All are perforate.

The types were supplied by Frick who gave no locality other than the "Sandwich Islands." In specimens collected by New-

comb at about the same time—almost sixty years ago—the color of the last whorl is a rich cinnamon, between raw sienna and ochraceous (of Ridgway's "Nomenclature of Colors"), fading upwards, and darker at the base (pl. 3, figs. 8, 9). This was evidently the coloration of Pfeiffer's type. Some of the Mapulehu shells are of this color, others being darker, as in those from Moanui.

At Moanui (pl. 14, fig. 1) the base of the last whorl is burnt umber, the upper part drab or olive, the transition often abrupt at the periphery. Frequently there are numerous umber bands occupying half the space between periphery and suture. The size is greater than at other localities up to length 23½, diam. 8⅓, and length 24, diam. 8 mm.

At Ahaino and Kupeke (pl. 14, figs. 2, 3, 4) the shells are small, the microscopic granulo-striation well developed, other sculpture obsolete. The last whorl is ochraceous with several umber bands and basal tract, or olive with an umber base. The largest shells are 18 mm. long, 6 wide, most being between 16 and 17 mm. long. This local race may be called var. *decorata*.

Specimens from Honomuni (pl. 14, figs. 6, 7) are very much lengthened, ochraceous, base a little darker, spire worn, dull violet or purple. Columellar reflection very small, adnate; a "false umbilicus" visible in basal view. Length 19, diam. 6 mm., whorls 6. This form may be called var. *honomuniensis*.

8*a*. N. c. UALAPUENSIS n. subsp. Pl. 2, figs. 11, 12.

Similar to *N. cumingi* in having well-developed spiral cords, but the surface between and over them is minutely but *strongly puckered or wrinkled longitudinally* (fig. 12), and not spirally striolate as in *cumingi* and *cinnamomea*.

Molokai: Ualapue (D. Thaanum), no. 94490 A. N. S. P.; Kahaanui (Thaanum).

The upper whorls are considerably eroded in the type lot, but the younger individuals show the striped pattern of *cumingi*. It is a little smaller than *N. cumingi*, length of figured type 20, diam. 6½ mm.

This race seems about equally related to *cumingi* and *cinnamomea*, with incipient characters of *pfeifferi*.

9. N. PFEIFFERI (Newcomb). Pl. 2, figs. 4, 8, 14.

"Shell sinistral, acuminate, turrited, with the surface irregularly cut up into furrows, ridges and tubercles by deep longitudinal sulcations crossed by strongly developed transverse striæ. Color brown, with white longitudinal lines on the upper whorls. Whorls 6, flatly convex; suture deep. Aperture oblong-ovate. Columella plain and smooth; outer lip simple. Length .65, diam. .25 inch" (*Newc.*).

Molokai (Newcomb): Puukolekole (Meyer); Kaluaaha (Baldwin).

Achatinella pfeifferi NEWCOMB, Ann. Lyc. Nat. Hist. of New York vi, p. 25 (May, 1853); P. Z. S., 1853, p. 150, pl. 24, f. 58 (1854).—*Newcombia pfeifferi* Newc., SYKES, Fauna Hawaiiensis, p. 332.—*Bulimus newcombianus* PFR., Monographia iii, p. 414 (1853); P. Z. S., 1851, p. 261 (December, 1853).—*Newcombia newcombiana* PFR., Malak. Bl. i, 1854, p. 119.—PEASE, P. Z. S., 1869, p. 649.—*A. newcombiana* THWING, Reprint Orig. Descript. Achat., 1907, pl. 3, f. 9.—*N. newcombia* Pfr., HARTMAN, Proc. A. N. S. Phila., 1888, p. 41.—BORCHERDING, Zoologica, p. 98, pl. 9, f. 5, 5*b*.

Very distinct by the coarse longitudinal folds and rude spirals of the last two whorls.

The initial half whorl is smooth; the next whorl has about 8 close, smooth spirals; on the following whorl these become more widely spaced, and a color pattern of broad brown and white longitudinal stripes appears, continuing to the end of the embryonic stage, which comprises $3\frac{1}{3}$ whorls. Weak folds then begin on the neanic stage, gradually becoming stronger, the color being indistinctly marbled with white on a dark brown ground. The last two whorls are brown with the high points of the ribs yellowish; the sculpture increasing in strength. There is a minute sculpture of irregular, crenulated striæ over the coarser ribs and cords. The whorls are strongly convex.

Length 15, diam. 6 mm.; $5\frac{1}{2}$ whorls.

Length 17, diam. 6 mm.; $6\frac{1}{3}$ whorls.

It varies in details of sculpture and in the degree of elongation.

Genus PARTULINA Pfeiffer.

Partulina Pfr., Malakozoologische Blätter, i, p. 114, 1854 (for *A. virgulata, tessellata, splendida, perdix, gouldi, dubia*).—Von Martens, Die Heliceen, 1860, p. 243, type *A. virgulata* Migh.—Gulick, P. Z. S., 1873, p. 90, same type.—Sykes, Fauna Hawaiiensis, p. 311, same type.

Includes as sections, *Perdicella*, *Eburnella* and *Baldwinia*.

Shell ovate-conic, usually *perforate*, and having distinct minute sculpture of *spirally descending rippled striæ*. Embryonic shell after the first whorl spirally striate. Color pattern of oblique stripes or spiral bands, the last embryonic whorl generally striped. *Lip expanded* more or less; columella folded or almost simple.

Type *Partulina virgulata* (Migh.). Distribution, Molokai, Lanai, Maui and Hawaii, one species on Oahu.

The *Achatinellinæ* of the islands from Molokai southeastward form a group of common ancestry, characterized by their spiral and decurrent sculpture, perforate axis, oblique stripes and spiral striæ on the early whorls, etc. Some or all of these characters may fail in particular species, but their general prevalence leads us to believe them the heritage from a common ancestral stock. The Oahuan *Achatinellinæ* do not possess the sculpture and color-pattern noted above as characteristic of the other islands, and evidently are more related *inter se* than to any Molokai-Hawaii snails. Although the difference between Oahuan and Molokai forms are sometimes elusive and not to be laid down in formal diagnoses, yet it may be allowable to express, by a generic separation, the idea that we have to do with two collateral stocks of arboreal snails, the one on Oahu, the other on the islands eastward.

Newcombia has the color and sculpture pattern of typical *Partulina*, but with other special modifications which make it advisable to treat that group as a genus.

Several subdivisions or sections of *Partulina* have been named. They are not of much systematic importance, and there are some intermediate species; yet as they seem to be natural groups we admit them here.

Sections of Partulina.

a. Columellar fold prominent, heavily calloused.

b. Spiral sculpture distinct, at least at the early whorls; shell not brilliantly glossy.

Section *Partulina* s. str., species 8–35.

*b*¹. Spiral sculpture weak or obsolete; shell smooth and glossy, light colored, uniform or banded.

Section *Eburnella* Pse., species 36–47.

*a*¹. Columellar fold wanting or weak, not calloused.

b. Spire slenderly conic; rather capacious forms; outer lip narrowly expanded.

Section *Baldwinia* Ancey, species 48–53.

*b*¹. Shell small, oblong or oblong-conic; outer lip not expanded.

Section *Perdicella* Pse., species 1–7.

Section Perdicella Pease.

Perdicella Pease, P. Z. S., London, 1869, p. 648.—Sykes, Fauna Hawaiiensis, Mollusca, p. 329, type *A. helena* Newc.

Small *Partulinæ* having protractive stripes on the last embryonic whorl, later whorls striped or with a peripheral band; sculpture Partulinoid; columella nearly straight, or if developed the columella fold is moderate, convex, scarcely or not truncate; outer lip thin, not expanded. Type *P. helena* Nc.

Perdicella differs from *Partulina* by the unexpanded outer lip, the weakness of the columella fold and the small size of the shell. In coloration and sculpture it is altogether Partulinoid. This affinity was recognized by Gulick, who in his classification of 1873 ranked *Perdicella* as a section of *Partulina*. Such species as *fulgurans*, *theodorei* and *winniei* are directly intermediate between *Perdicella* and *Partulina*. *Perdicella* is not closely related to *Baldwinia*, although in both the columellar fold has degenerated. It is a branch from the *tessellata* or *marmorata* series of Partulinæ.

Key to Species of Perdicella.

a. Molokai. Shell sinistral, usually with a light or dark band.

P. helena, no. 1.

a^1. Maui.

b. Shell sinistral, with long, straight-sided spire, finely zigzag-streaked or speckled, with a dark peripheral band. *P. ornata*, no. 2.

b^1. Shell dextral, oblong or ovate-conic.

c. Columellar fold distinct, convex.

d. Pattern of longitudinal chestnut lines, base umber with a spiral umber band; col. fold prominent; length 14 mm. *P. zebra*, no. 3.

d^1. Boldly striped or zigzag-striped, without a spiral band; columella white or pink, with a rather strong fold.

e. Length about 13 mm.; form narrow. *P. zebrina*, no. 5.

e^1. Length about 15–16 mm.; form wider. *P. fulgurans*, no. 6.

c^1. Columellar fold very weak.

d. Lip and columella brown; diam. not much over half the length. *P. mauiensis*, no. 4.

d^1. Columella white or tinged with purple-brown; diam. nearly two-thirds the length. *P. kuhnsi*, no. 7.

1. P. HELENA (Newcomb). Pl. 4, figs. 1 to 7.

Shell sinistral, ovate-conical, with finely decussating striæ; rufous, alternating with broad longitudinal zigzag white lines covering the entire shell; the last whorl often encircled by a white band. Whorls 5, rounded; suture deep, simple. Aperture ovate, columella slightly callous. Length 0.5, breadth 0.22 inch (*Newcomb*).

Molokai, on the Ti tree (Newcomb). Kamalo to Kalae (Baldwin); Kalae and Makakupaia (Perkins); Kealia (Meyer).

Achatinella helena NEWC., Annals Lyceum of Nat. Hist. of N. Y. vi, p. 27, April, 1853; P. Z. S., 1853, p. 151, pl. 24, f. 63; 1854, p. 311.—PFR., Monogr., iv, 561.—*A.* (*Partulina*) *h.*, BALDWIN, Catalogue p. 6.—*Perdicella helena* NC., PEASE, P. Z. S. 1869, p. 648.—SYKES, Fauna Hawaiiensis, p. 330.—BORCHERDING, Zoologica, p. 75, pl. 4, f. 17 (Kealia), and 18 (Maka-

kupaia).—Thwing, Reprint Orig. Descript. Achat. p. 134, pl. 3, fig. 5.

Newcomb states that *A. helena* "is extremely limited in its locality, which has been twice carefully searched by myself without discovering larger specimens, dead or alive, that approached it in form. Several of the specimens contained young in the oviducts." It was taken "within the coil of the Ti tree leaf, as it starts from the trunk."

The shell is sinistral, perforate; summit obtuse. There are fully 2½ convex embryonic whorls, the initial half-whorl smooth, the next two evenly, rather strongly striate spirally; last embryonic whorl is variegated with broad, forwardly descending, brown and white flames. The neanic and last whorls have a much finer and very close spiral sculpture of minutely waved or crinkled striæ, and a variable pattern of zigzag streaks, interrupted by a cream-white peripheral belt; the axis in a light area. The outer lip is thin, columella very short, with a rather strong callous fold, and broadly but shortly dilated.

Length 11.3, diam. 6.7, aperture 5.3 mm.; 5⅓ whorls.

Length 12.2, diam. 6.5, aperture 6 mm.; 5½ whorls.

Fig. 3 represents a typical specimen. Five specimens from Newcomb, and others from Baldwin, the University of Wisconsin, Cooke collection, etcetera, examined. There is considerable variation in details of color-pattern, as in all related species. Sometimes the stripes on the later whorls are smeared or partly defaced, reduced to indistinct streaks. Occasionally the whitish subperipheral belt does not appear until near the end of the last whorl (fig. 4, Cooke coll.), or it may be entirely absent (fig. 2). The color of the peripheral band, like the ground-tint of the shell, varies from whitish to yellow.

Color var. *balteata* n. v. has a single brown belt at the periphery, continuous or indistinctly interrupted, on a pale fleshy or brown-tinted ground, the flames of the last embryonic whorl faint (pl. 4, fig. 7).

A pretty color-form in the Cooke collection has the periphery occupied by a series of dark spots, oblique in one example, chevron-shaped in another, the flammules elsewhere reduced to weak streaks or spots (fig. 6).

Var. *minuscula* Pfeiffer. Pl. 5, fig. 6. Shell subimperforate, sinistral, ovate-turrite, rather thin, under a lens minutely decussate, scarcely shining, brown-whitish; spire turrite-conic, the apex slightly obtuse; suture simple. Whorls 5, very slightly convex, the intermediate ones variegated with brown, last whorl a little shorter than the spire, encircled with a brown band and with a brown area on the rotund base. Columella scarcely plicate, semioval; peristome simple, acute, the columellar margin dilated above, reflexed. Length 10, diam. 5 mm.; aperture $4\frac{1}{2}$ mm. long, $2\frac{2}{3}$ wide (*Pfr.*).

Molokai Mountains at 4000 ft. (Perkins). Sandwich Islands (Frick in Cuming coll., type loc.).

Achatinella minuscula Pfr., Malak. Bl., iv, 1857, p. 231; P. Z. S., 1858, p. 22, pl. 40, f. 10; Monographia, iv, 562.—*Perdicella m.*, Pease, P. Z. S., 1869, p. 648.—Sykes, Fauna Hawaiiensis, p. 330.—*Cf.* Borcherding, Zoologica, p. 76.

Pfeiffer's figure, which we copy, shows a color-pattern like that of some immature specimens of *helena*. Borcherding considers it a synonym of that species, an opinion which I think well-founded. It seems to be a wider shell than the dextral *P. zebrina* Pfr., which it resembles closely in coloration. Mr. Baldwin reported *minuscula* from Lahaina, Maui, evidently confusing it with the quite different *P. kuhnsi*.

2. P. ornata (Newcomb). Pl. 4, figs. 8, 9, 10.

"Shell sinistral, acutely pyramidal, shining; whorls 6, planoconvex, margined above; suture well-impressed; aperture subquadrate in adult, subovate in immature shells; lip slightly thickened at the edge; columella broad and flattened; surface of shell covered with alternating undulations or zigzag markings of white and black arranged longitudinally, with a subcentral transverse black band, sometimes margined with a white one below on the last whorl. Length 10, width 4 twentieths of an inch" (*Newcomb*).

East Maui: in a deep ravine back of Lahaina (Newcomb, type loc.). West Maui: Mt. Helu, 4000 ft. (W. F. Kaae).

Achatinella ornata Newc., P. Z. S., 1853, p. 149, pl. 24, f. 55.—Pfr., Malak. Bl. 1854, p. 118; Monogr. iv, p. 561.—

THWING, Reprint Orig. Descript. Achat., p. 136, pl. 3, f. 7.—*Perdicella ornata* Nc., BALDWIN, Nautilus, xix, p. 113.

A rare species, of which twenty specimens from the Newcomb and Gulick collections, taken 50 to 60 years ago, are before us, all "dead" shells, and a smaller series of "live" shells from Baldwin. The straightly pyramidal spire and subangular periphery give the shell an aspect of its own. The suture is very distinctly margined by a band defined by an impressed line in some shells, but in most of those seen there is no trace of such margination.

First $1\frac{1}{2}$ or 2 whorls are flesh or whitish flesh-colored; next half whorl has broad flexuous or irregular flesh-brown and white stripes; after which the brown markings become narrow, zigzag, and on the last whorl they are often dislocated, spotted or mottled, though sometimes distinctly striped as in Newcomb's type figure. On the last whorl there is a subperipheral brown belt in all the specimens seen. It is bordered below by a pale or cream-colored belt, more or less distinct. The columella is dilated above in a small triangle, calloused, and convex, obliquely trancated far above the base.

Length 14.8, diam. 6.5, aperture 6 mm.; 6 whorls.

Length 14.8, diam. 6, aperture 5.8 mm.; $6\frac{1}{3}$ whorls.

3. P. ZEBRA (Newcomb).

"Shell dextral, conically elongate, shining, with microscopic decussating striæ; whorls $5\frac{1}{2}$ round, narrowly margined above, suture well marked; aperture ovate; lip thin; columella short, abruptly terminating in a large prominent plait; color of epidermis yellowish white, alternating with longitudinal chestnut lines; base of an umber color, with a revolving line of the same color above. Length 11, width 5 twentieths of an inch" [$13\frac{3}{4} \times 6\frac{1}{4}$ mm. (*Newc.*)

East Maui (Newcomb).

Achatinella zebra NEWC., Annals of the N. Y. Lyceum of Natural History, vi, p. 142, Oct., 1855.—PFR., Monogr. ix, 537.

Described from a single specimen, and not figured. It seems to resemble *P. ornata* in color-pattern, differing from *zebrina* Pfr. by the basal band.

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4. P. MAUIENSIS (Pfeiffer). Pl. 4, figs. 11, 12, 13, 14.

Shell subperforate, ovate-oblong, rather thin, longitudinally, irregularly striate, decussated with very close spiral striæ visible under a lens, hardly shining; whitish, variegated with serrated brownish-corneous streaks. Spire regularly conic, apex obtuse, suture shallow, slightly margined. Whorls $5\frac{1}{2}$, rather flat, the last nearly two-fifths the total length, somewhat tapering at the base. Aperture little oblique, oblong. Columellar fold obsolete. Peristome simple, unexpanded, brown-bordered, the columellar margin reflexed, subadnate. Length 13, diam. 6, aperture 6 x 3 mm. (*Pfr.*).

West Maui (Newcomb); Makawao to Huelo (Baldwin).

Achatinella maniensis Newc. [typogr. err. for *mauiensis*] PFEIFFER, P. Z. S., 1855, p. 207 (1856).—*A. mauiensis* Newc., PFR., Monographia, iv, p. 563.—NEWCOMB, Amer. Journ. of Conch., ii, 1866, p. 217, pl. 13, fig. 16.—THWING, Reprint Orig. Descript. Achat., p. 134, pl. 3, f. 6.

The shape and coloration are about the same as in *P. zebrina* Pfr., but the aperture is dark brown within (sometimes overlaid with whitish), and the brown columella has only a low fold situated high, and not heavily calloused, much as in some Bulimuli. The whorls of the spire are sometimes distinctly margined below the suture. Figured from shells received from Baldwin. Length 12.2, diam. 6.2, aperture 6 mm.; $5\frac{1}{3}$ whorls.

5. P. ZEBRINA (Pfeiffer). Pl. 5, figs. 5, 8 to 12.

Shell imperforate, dextral, rather thin, smooth, very minutely decussate under a lens; glossy; whitish, very elegantly marked with blackish-chestnut zigzag streaks. Spire somewhat turrited, apex obtuse, brown; suture with a thread-like margin. Whorls 5, moderately convex, the last nearly three-sevenths the length. Aperture slightly oblique, truncate-oblong, lilac within; columellar fold above, twisted, callus, slightly prominent. Peristome simple, unexpanded, brown-bordered. Length $12\frac{1}{2}$, diam. 6, aperture 6 x 3 mm. Sandwich Is., Frick in Cuming coll. (*Pfr.*).

East Maui: Honomanu (Baldwin).

Achatinella zebrina Pfr., P. Z. S., 1855, p. 202 (1856); Monographia, iv, 561.—*A. zebra* Nc., Baldwin, Catalogue, p. 7.

"Related to *A. ornata* Newc., but dextral and quite distinct in the characters of the aperture" (*Pfr.*).

This species is known to us by specimens collected by Mr. Baldwin. About $1\frac{3}{4}$ whorls at first are uniform light reddish brown. The next half-whorl has wide alternating, more or less forwardly-descending stripes of white and dark brown. After that, the stripes become narrower, more sharply defined, and more or less irregular or dislocated, the light and dark stripes being about equal in width. The ground remains white nearly to the base in some shells, in others becoming coffee-tinted, darkest at the base. The spiral striation of the embryonic shell is extremely delicate. The interior is purplish in fully adult shells. The columella has a rather heavy callous fold, situated high, or sometimes heaviest at the lower end, but there is no lamella properly speaking. The axis is imperforate. Length 13.2, diam. 7, aperture 6 mm. $5\frac{1}{2}$ whorls.

P. zebrina differs from *P. mauiensis* chiefly by the much more prominently folded and calloused white or flesh-tinted columella.

6. P. fulgurans (Sykes). Pl. 5, figs. 1 to 4, 7.

Shell subperforate, dextral, ovate-turrited, glossy, closely sculptured with spiral lines under a lens, whitish, very elegantly marked with zigzag chestnut stripes. Suture moderately impressed, the apex rather obtuse. Whorls $5\frac{1}{2}$, plano-convex, the last two-thirds the length of the shell. Aperture ovate-piriform, lilac within; right margin of the peristome simple, columellar margin somewhat reflexed; columellar fold twisted, somewhat projecting, moderate, rapidly ascending. Length 16, diam. 8, length aperture 8.1 mm. (*Sykes*).

East Maui: Makawao to Huelo (Baldwin).

Achatinella zebrina Pfr., Baldwin, Catalogue p. 8, not of Pfeiffer.—*Perdicella zebrina* Pfr., Borcherding, Zoologica xix, p. 77, pl. 4, f. 19.—*Perdicella fulgurans* Sykes, Fauna Hawaiiensis, Mollusca, p. 329, pl. 11, f. 5, 1900.

"This very pretty shell is akin to *P. zebrina* Pfr., but may

be readily separated from it by its greater size, by being much broader in proportion to the length, and by the color-pattern being finer in design and more zigzag'' (*Sykes*).

The embryonic shell is like that of *P. zebrina*, and the sequence of patterns exactly similar. An almost fully formed embryo is 4.2 mm. long, imperforate, with a straight, very slightly calloused columella, $2\frac{1}{2}$ whorls.

The columella resembles that of *P. zebrina*, and is much more strongly twisted than in the East Mauian *P. mauiensis*. The color-design is variable, but a majority of the shells before us are similar to fig. 7. Mr. Sykes's original figure is copied, fig. 4.

Length 15, diam. 8, aperture 7.6 mm.; $5\frac{1}{2}$ whorls.

Length 13, diam. 7.8, aperture 6.7 mm.; (not quite mature).

7. P. KUHNSI Pilsbry, n. sp. Pl. 14, figs. 8, 12–15.

The shell is dextral, perforate, conic, thin; outlines of spire straight; whorls moderately convex. Embryonic whorls white or brownish, uniform or more frequently having festooned axial stripes or two bands of lunate spots on the last half-whorl. Subsequent whorls maculate with brown; the last whorl streaked and maculate with brown, and encircled with white bands, of which one on the upper surface, another below the periphery and an umbilical area are the most constant. Other specimens have the last embryonic whorl broadly striped with brown, last whorl copiously zigzag-striped with chestnut on a white ground; this pattern is sometimes interrupted by one or two white spiral bands. Surface glossy, densely and minutely striate spirally, the striation weak on the last whorl. Growth-striae weak. Aperture white within; peristome thin, unexpanded; columella white, or having a brown or purplish stain in the lower part, nearly straight, but in oblique view a low fold is visible within; sometimes the fold is obvious in a front view; outer edge triangularly reflected.

Length 13.2, diam. 8 mm.; whorls $5\frac{1}{2}$.

Length 12, diam. 7.2 mm.

West Maui: Honokohua, type loc.; Honokowai; Mt. Lihau; Mt. Helu; Mauna Hoomaha; ridges above Lahaina; Hailaau;

Kapuna; Moomuku and Honolua (Thaanum). Cotypes in coll. Bishop Museum and A. N. S. P.

Achatinella minuscula Pfr., Thwing, Reprint Orig. Descript. Achat., 1907, pl. 3, f. 8.—? *Achatinella minuscula* Pfr., Baldwin, Catalogue p. 6, 1893. Not *A. minuscula* Pfr.

"Not common anywhere, but a widely distributed species. It is undoubtedly the *Part. minuscula* Pfr. of Baldwin's Catalogue" (*Thaanum*).

It differs from *P. zebrina* Pfr. and *fulgurans* Sykes by the much more slender conic spire, which resembles that of *P. helena*.

This is a polymorphic species in which several mutations have been established in the same colony. The original pattern was probably zigzag-striped, the derivatives differing by the development of white zones and coalescence of the interrupted stripes in a spiral direction. Figs. 12 to 15 represent shells from the type locality, 12 and 14 being the prevalent color-forms.

Shells from Honokowai (pl. 14, fig. 8) are snow-white above the periphery, yellow below it, the periphery marked by a band of chestnut spots. There is also a very narrow dark crescent behind the columella and some indistinct dark streaks and spiral lines on the base. Length 14.5, diam. 8.8 mm. I have not seen specimens from the other localities given by Mr. Thaanum.

This species is named in honor of Mr. D. B. Kuhns, to whose ability in the field we owe many new and interesting *Achatinellidæ*.

Section Partulina (restricted).

Larger, more capacious shells than the *Perdicellæ*, and having the columellar fold well calloused, and the outer lip usually well expanded, thickened within. Sculpture and color-patterns about the same. They live on Molokai (species no. 8 to 15), Lanai (species no. 16), and Maui (species 17 to 35).

Species of Molokai.

Key to Achatinellinæ of Molokai.

Note.—Yellow forms plain or with zigzag black stripes should be looked for in *Laminella*, Vol. XXI, p. 345.

A. Shell elongate, dull, with distinct or strong spiral sculpture, the columellar fold weak or wanting.

Newcombia, p. 1.

A^1. Shell very glossy and smooth, porcelain-like, coloration light and in bands, never longitudinal stripes or flames; columellar fold strong.

a. Shell dextral.

b. Spire long; shell white, uniform or with gray or light brown streaks, generally having a subperipheral dark band or several bands; length 16–19 mm. *mighelsiana*, no. 45.

b^1. Spire shorter, concavely conic, the last whorl bulging; yellow, usually with a chocolate subsutural line or band; length 13–18 mm. *polita*, no. 44.

b^2. Spire straightly conic, last whorl not bulging, color various. *bella*, no. 42.

a^1. Shell sinistral, obesely ovate-conic, yellow, the embryonic whorls white with a dark band.

subpolita, no. 43.

A^2. Shell ovate-conic or pyramidal, showing moderate sculpture under a lens; last embryonic whorl usually variegated; columellar fold well developed.

b. Embryonic whorls having a dark spiral band.

virgulata, no. 8.

b'. Embryonic whorls having vertical or protractive stripes, or sometimes plain.

c. Ovate-conic, rather large, length usually 23 to 26 mm.

d. Surface dull, fine spiral sculpture being well developed; banded or streaked.

rufa, no. 10; *tessellata*, no. 9.

d^1. Surface glossy; striped or plain.

proxima, no. 11.

c. Narrower, pyramidal-conic, sinistral.
d. Small, length 11 to 13 mm. *helena*, no. 1.
*d*¹. Larger, length over 17 mm.
e. Longitudinally boldly striped throughout; length 18 mm. *theodorei*, no. 12.
*e*¹. Suture bordered below by a dark band, others at periphery and columella; lip narrow, white; length 20 to 22 mm. *mucida*, no. 13.
*e*². Suture bordered by a white band or line; lip and columella brown; length 21 to 25 mm. *redfieldi*, no. 15.
*e*³. No conspicuous sutural border; variously streaked, often with a subperipheral white band, rarely others; lip wide, both lip and columella white; length 22 to 26 mm. *dwightii*, no. 14.

Series of P. virgulata.

Embryonic whorls bicolored, having an upper white and lower dark spiral zone; later whorls varying from many-banded to plain. Shell either dextral or sinistral.

While this group has the characteristic sculpture and form of the other Partulinæ, it is remarkably aberrant in the color-pattern of the embryonic whorls.

8. P. VIRGULATA (Mighels). Pl. 6, figs. 1 to 6, 9, 10.

"Shell ovate-conic, light fawn color, beautifully adorned with dark brown bands, more or less numerous; imperforate; whorls 5, convex; incremental striæ delicate. Aperture oblong; lip reflected, slightly inflected. Length 1 inch, diam. $\frac{3}{5}$ inch" (Mighels).

Embryonic whorls nearly 3, the first purple-brown, the next bicolored, having a wide snow-white band below the suture. A narrow, more or less distinct cream-white subsutural band continues to the end. Spiral bands appear about the middle of the first neanic whorl, are often pale at first, becoming dark chestnut on the last whorl, which is variously marked with

lines and bands. Under a glass the spiral striation is dense and deeply cut, the striæ rippled and descending. The axis is either closed or slightly open. Lip slightly expanded and well thickened within. The columella is reflexed in a short, wide triangle, and the columellar fold varies from distinct to weak.

Length 25 to 26, diam. 15.2, length aperture 14 mm.

Length 22.5, diam. 15, length aperture 13 mm.

Length 23, diam. 14, length aperture, 11.6 mm.

Length 21, diam. 12.3, length aperture 10.5 mm.

Molokai, in the eastern part, Ualapue, Kaluaaha, Mapulehu, Waialua, Halawa and Pelekunu (Meyer).

Partula virgulata Mighels, Proc. Boston Soc. of Nat. History, II, 1845, p. 20.—Pfr., Monogr., iii, p. 454.—*Achatinella virgulata* Migh., Reeve, Conch. Icon., pl. 1, figs. 3, 4, 5, 5b.—Newcomb, P. Z. S., London, 1854, p. 311; Lyc. N. H. of N. Y., vi, 1858, p. 312 (description of animal).—Thwing, Reprints Orig. Descript. Achat., pl. 2, f. 8.—*Partulina virgulata* Migh., Borcherding, Zoologica, xix, Heft. 48, p. 50, pl. 1, figs. 1–20.—*Achatinella rohri* Pfr., P. Z. S., 1846, p. 38.—*Bulimus rohri* Pfr., Zeitschrift für Malak., 1846, p. 115; Monographia, ii, p. 74.—*Bulimus insignis* Mighels on labels, Reeve, Conch. Icon., Achatinella, species no. 3.—*Achatinella virgulata* var. *halawaensis* Baldwin in coll., Borcherding, Zoologica, xix, p. 52, pl. 1, f. 13–16, 1906.

This species is well distinguished by the broad band above the suture on the embryonic whorls, usually purple-brown but sometimes yellowish and quite pale, and the total absence of flame markings. It is indifferently dextral or sinistral.

The typical form (pl. 6, figs. 1, 3), such as occurs at Mapulehu, while varied a good deal, is rarely so dark as the forms from the neighboring valley Kaluaaha, in which the light ground is often reduced to narrow lines; or in Ualupue, the next valley westward, the light ground is altogether extinguished (figs. 5, 6). These dark shells are very glossy, with *much fainter spiral* striæ than the typical form, which has little or no gloss. Fig. 9 represents a form from Ualupue, fig. 10 from Pelekunu, after Borcherding. Uniform purplish-flesh tinted examples, without bands on the post-embryonic whorls, perhaps occur in all the

colonies. They are present in the lots of the typical form which I have seen.

8*a*. Var. *halawaensis* Baldwin (pl. 6, figs. 7, 8, 11), which occurs further east at Halawa, is white or pale straw-colored, becoming darker towards the outer lip, without post-embryonic bands, or with them narrow and few; lip brown-edged within. Dark band on the embryonic shell normal, or rarely much reduced. Contour long. Length 28, diam. 15.2, aperture 15 mm.

A peculiar form (pl. 6, fig. 2) from the University of Wisconsin collection has the embryo white with a narrow chocolate band, the last $2\frac{1}{2}$ or 3 whorls fawn with many narrow longitudinal darker streaks and only faint traces of spiral bands. The shell is very glossy and small, length 19.7 to 20.5 mm. Exact locality of these specimens unknown, but Herr Borcherding, who has given a magnificent plate of 40 figures to the forms of *virgulata*, figures this race from Pelekunu, on the northern water-shed, together with small, slender, nearly white examples.

It is evident that a good deal of local differentiation has taken place among the colonies of *virgulata*.

A. rohri was acknowledged by Pfeiffer to be a synonym of *virgulata*. It was thus described: "Shell perforate, ovate-conic, rather solid, longitudinally striatulate, decussated by very close spiral striæ; whitish fulvous, variously ornamented with narrow chestnut bands; spire conic, rather acute. Whorls 6, but slightly convex, the last about as long as the spire, compressed in the middle. Columella twisted, callous. Aperture subtetragonal, glossy white within; peristome slightly expanded, labiate within, the margins subparallel, the right margin shortly arcuate above, columellar margin reflexed, nearly closing the perforation. Length 24, diam. 13, aperture 13 mm. long, $6\frac{2}{3}$ mm. wide inside."

Group of P. tessellata.

Embryonic whorls unicolored or having obliquely axial stripes.

9. P. TESSELLATA (Newcomb). Pl. 6, figs. 12 to 21.

"Shell sinistral, ovate-oblong, solid, with minute decussating striæ, color white or fawn-colored, variously striped or not with black and chesnut bands, upper whorls always tessellated with black and white; whorls convex, the last somewhat inflated; aperture white or roseate, ovate, effuse below; columella short and broadly callous; columellar lip broad and slightly reflected. Length 1 to 1.1 inch; breadth 0.6 inch.

"Body light gray, mantle slate color" (*Newc.*).

Molokai (Newc.): Kalae, Kealia, Kalawao, Kahanui, Makakupaia, and Pelekunu valley (Meyer).

Achatinella tessellata NEWC., Ann. Lyc. N. H. of N. Y., vi, p. 19, May, 1853; P. Z. S., 1853, p. 139, pl. 23, fig. 26; 1854, p. 311.—PFR., Monogr., iv, p. 516.—SYKES, Fauna Hawaiiensis, p. 319.—THWING, Reprint Orig. Descript. Achat., pl. 2, f. 6.—*Partulina tessellata* Newc., BORCHERDING, Zoologica, p. 52, pl. 2, figs. 1 to 16, 1906.

Out of 57 specimens before me, 53 are sinistral. The figure is stouter than in the following species, and it differs from *virgulata* constantly by the obliquely striped last whorl of the embryo. The first 1 to $1\frac{1}{2}$ whorls are some shade of brown; then broad, slightly retractive stripes of opaque white and dark brown alternate to the end of the embryonic shell. A clouded or zigzag-mottled pattern ensues on the first neanic whorl. The umbilicus is narrowly perforate, and the surface has little gloss or none, the dense, wavy, spiral lineolation being well developed.

Length 26, diam. 17.3, aperture 14 mm.

Length 23, diam. 15.5, aperture 12 mm.

The typical form probably came from Makakupaia (pl. 6 figs. 16, 18, and fig. 12 received from Newcomb). The ground-color of the later whorls is whitish, more or less streaked with fleshy, with a varying arrangement of dark spiral bands and lines; lip light liver-brown. Rarely the bands are absent, the later whorls being profusely streaked (pl. 6, fig. 17).

At Kahanui most specimens have the post-embryonic whorls uniform reddish-chocolate, by coalescence of the bands, or they are banded with that color (figs. 13, 14, 15, 20), but some

specimens resemble the typical form in pattern. They occur both sinistral and dextral, the latter rare.

From Kealia Borcherding figures shells with very weak or light chestnut bands (fig. 19).

In the C. M. Cooke collection there is a set of nearly white shells (fig. 21).

9*a*. P. T. MEYERI Borcherding. Pl. 7, figs. 1, 2.

"Shell narrowly umbilicate, dextral, rather solid ovate-conic, under a lens decussated regularly and very finely, glossy; pale gray or grayish-brown, ornamented with light and darker brown, or with gray and blackish streaks; spire conic, the apex rather obtuse; suture crenulated, more or less margined, whorls 6, convex, the last $\frac{1}{2}$ the total length; upper whorls tessellated with reddish-gray and yellowish-gray, the last whorl rounded, uncolored, or under the middle having narrow horn-colored bands here and there. Aperture inversely ear-shaped, glossy bluish within; peristome narrowly expanding and thickened, with a reddish-brown internal lip. Columella twisted, calloused; columellar margin reflexed, nearly covering the umbilicus. Length 22 to 24, diam. 13, aperture 12 × 8 mm." (*Borcherding.*)

Molokai: Pelekunu (Meyer).

Partulina meyeri BORCHERDING, Nachbl. d. d. Malak. Ges. 1901, p. 55; Zoologica xix, p. 54, pl. 2, f. 17, 18.

Found in Pelekunu valley, where a large, dextral form of *tessellata* reminding one of *virgulata* also occurs.

10. P. RUFA Newcomb. Pl. 7, figs. 3 to 11.

"Shell sinistral, conically ovate, solid, with decussating striæ; ground color externally and internally brownish red, covered with an epidemis of a mottled brown and white, the latter arranged on the central whorls in fine zigzag markings, which are lost on the last whorl in a uniform grayish umber; lower half of this whorl encircled by a broad white band, whorls 6, flatly convex; suture plain, moderately impressed. Columella strongly callous ; umbilicus open, small. Lip expanded, reflected below. Length 0.9, breadth 0.5 inch" (*Newcomb*).

Molokai (Newcomb): Kalae, Kaweeku, Kalamaula, Kahanui and Makakupaia (Meyer), in the central part of the island.

Achatinella rufa Newc., Ann. Lyc. N. H. of N. Y. vi, p. 21, May 1853; P. Z. S. 1853, p. 130, pl. 22, fig. 3; Ann. Lyc. vi, p. 324 (description of animal).—Pfr., Monographia iv, 537.—Sykes, Fauna Hawaiiensis p. 318.—*Partulina rufa* Nc., Borcherding, Zoologica xix, p. 54, pl. 3, f. 1–9.—*Partulina idæ* Borcherding, Nachrbl. d. d. Malak. Ges. 1901, p. 52; Zoologica p. 56.

(1) Typical *P. rufa* (pl. 7, fig. 3) is a dull shell with the growth-lines usually strongly marked, unequal, crossed by low, usually wide and more or less *granulose spirals* mingled with finer waved striæ, the latter often predominating, especially below the periphery. The sculpture is extremely variable, the granulose spirals being very strong in some forms, such as that described as *idæ*, and in others much reduced, the finer decurrent striation then dominating. The summit is yellowish-brown; last $1\frac{1}{2}$ or 1 embryonic whorls are marked with protractive yellowish-brown and white stripes; following neanic whorls have a dense, confused zigzag pattern, often indistinct or illegible. This may continue on the upper half of the last whorl, or it may be replaced by a uniform or clouded tawny color, interrupted by a white or yellowish belt just below the periphery. The columellar fold is strong, calloused, brown tinted, the lip of similar tint; interior pink or dull brownish-violaceous. Length 24, diam. 13.5, aperture 11.7 mm.

The original locality on Molokai is uncertain. Borcherding figures various forms from localities in the mountains south of the northern peninsula, none of them just like the typical form, represented by specimens before me received from Newcomb. Borcherding tentatively suggests the view that *P. rufa* is "not a pure species, but a bastard-form between *P. tessellata* Newc. on the one side, and *P. proxima* Pse. on the other." While this seems rather doubtful, and probably could be proved only by breeding experiments, *rufa* certainly unites characters of the two species. The embryo has protractive stripes as in *P. proxima*. Some very rare color-forms closely resemble *proxima* in the later stages; but it differs from that species by the dull

surface, deeply sculptured spirally; *proxima* being glossy, with weak spirals and very slight trace of the minute, wavy, spiral lineolation of the dull Partulinas. Pl. 7, figs. 6, 7 represent two forms of *rufa* from Kaweeku, copied from Borcherding.

(2) There is a dull brown (reddish to olive brown) form, with a few scattered light spots, much as in a common form of *P. marmorata* (pl. 7, fig. 4). Sometimes this form has a subperipheral white zone (fig. 5); the sculpture either as in var. *idæ* or without major spirals, clothed throughout with minute, crinkled, spirally descending striæ.

(3) Another form has zebra-stripes of white and brown, exactly as in one form of *proxima*, the surface having fine deeply cut *Partulina* sculpture. Length 28.5, diam. 16.5, aperture 15 mm.; whorls 7 (fig. 8).

(4) Similar to var. *idæ*, except that the spiral engraving is close, nearly even, without granules. Last whorl of the embryo having very obliquely protractive brown stripes; following whorls pale yellow, darker towards the base, or showing some faint tawny stripes on the spire. Aperture pinkish white, columella and narrow lip pale flesh-pink. Pl. 7, fig. 9, 10, 11.

Length 23, diam. 14.2, aperture 12 mm.

Length 17, diam. 10.2, aperture 8.2 mm.

(5) *Partulina rufa* var. *idæ* Borcherding (pl. 7, figs. 13, 14, 15), from Kalae and Kealia, may easily be recognized, according to Borcherding, by its compressed and ventricose shape and the regularly granulose spiral sculpture (fig. 13). The last whorl is more or less distinctly uniform yellowish-brown, or has a yellowish-white belt below the middle, the upper whorls being zigzag marked. In a series of 40 specimens before me I find the characters so variable that I cannot look upon *P. idæ* as anything but a local race. The sculpture in particular intergrades perfectly with typical *P. rufa*.

In many specimens of *idæ* the color above the periphery is pale or even whitish, and on the base it becomes yellow, rich brownish-yellow or olive, the change being gradual in some, abrupt in other examples. In many of the pale forms the stripes of the last embryonic whorl are faint or even not discernible.

11. P. PROXIMA (Pease). Pl. 9, figs. 1 to 9.

Shell sinistral, imperforate, oblong-ovate, ventricose; rather solid; finely striated transversely, striæ somewhat flexuous, granulose and interrupted, more regular and conspicuous beneath the sutures. Whorls 6, convex, marginated, the last being somewhat produced obliquely and flattened on the middle, so as to give in some specimens a subangulated appearance at the base. Aperture somewhat oblique, of an oblong-ovate form; columellar fold strong. Color chestnut-brown, striped and mottled irregularly with darker brown and white; columella and inner edge of aperture purplish red (*Pease*).

Molokai (Pse.): Maunahui, Kahanui, Waikolu, Makakupaia, Pelekunu, Makolelau and Kamalo (Meyer).

Helicter proximus PSE., P. Z. S., 1862, p. 6.—*Achatinella proxima* Pse., PFR., Monographia, vi, 1868, p. 168; viii, p. 217.—HARTMAN, Proc. Acad. Nat. Sci., Phila., 1888, p. 27, pl. 1, f. 1, 2.—*Partulina proxima* Pse., BORCHERDING, Zoologica, xix, p. 63, pl. 4, f. 1–12.

"The above species from the island of Molokai appears to represent the *H. marmoratus* and its varieties of the island of Maui. It is, however, larger and heavier; the last whorl has also a peculiar shape, in common with that of several of the larger species found on Molokai. All the specimens I have seen are sinistral, and the columella and edge of the aperture of a deep red" (*Pease*).

The first $1\frac{1}{2}$ whorls are white; then very obliquely protractive brown stripes appear, continuing to the end of the embryonic stage, which comprises $3\frac{1}{3}$ whorls. The succeeding neanic stage has stripes in general parallel to the growth-lines, but more or less interrupted or irregular. This pattern may continue to and upon the last whorl (figs. 1, 5); or the stripes may become nebulous or reduced on the last two whorls. The ground-color varies from glossy white to strongly brown tinted, or the last whorl may be brown tinted towards the base, white above. In some shells the stripes are very obliquely retractive on the later whorls (fig. 2).

In another variety the stripes are tawny yellow on a white or slightly coffee-tinted ground. The sutural margination is dis-

tinct (figs. 7, 8). According to Borcherding, this pattern comes from Pelekunu.

Another form has close hair-like lines, of brown, cream, and pale lilac, in harmony with growth-lines, over the whole post-embryonic shell. It is glossy, with typical embryonic coloration (fig. 9). Borcherding figures a shell of this pattern from Makakupaia.

In fully adult shells the outer and basal lips expand slightly. The lip and columella are brown in nearly all specimens, but in some light ones it is a vinous brown. The interior varies from nearly white to lilac or violaceous of various tints. *The surface is glossy*, and the *spiral striæ weak* or subobsolete.

Length 26.5, diam. 15.5, aperture 14 mm.; $6\frac{3}{4}$ whorls.

Length 24, diam. 14, aperture 13 mm.; $6\frac{1}{2}$ whorls.

Color-var. *schauinslandi* Borcherding. Pl. 9, figs. 10, 11.

The shell is very glossy, white or yellowish white, uniform or with faint, pale buff lines along growth lines on the last one or two whorls. Interior white or pink, the narrow lip roseate-brownish or nearly white, collumellar fold fleshy brown. The suture has a distinct narrow margin defined by an impressed line. Length 24, diam. 13, aperture 12 mm.; $6\frac{1}{2}$ whorls.

Young shells are sometimes white above, yellow below the angular periphery. In some specimens there are faint stripes on the last embryonic whorl. These are transitions from *schauinslandi* to the paler forms of *proxima* such as that from Pelekunu valley, clearly showing its genesis from the latter, the only difference being loss of color. This has been fully set forth by Herr Borcherding, and is well shown by the large series I have examined.

Molokai: Kaluahauoni and Waileia (Meyer).

12. P. THEODOREI (Baldwin). Pl. 9, figs. 14, 15.

Shell sinistral, minutely perforate, rather thin, narrowly pyramidal, glossy, with sculpture of rather rude growth lines and minute, rather weakly incised, spiral striæ. Embryonic whorls whitish, the last one usually marked with broad, protractive brown stripes. Following whorls have irregular purple-

brown flames or streaks on a white ground, in general harmony with growth-lines, widening downwards, scarcely reaching to the suture above. On the last whorl the streaks are often somewhat dislocated. Whorls nearly 7, but slightly convex, the suture rather indistinctly margined below. Aperture small, lilac within; lip narrow, not expanded or noticeably thickened, brown-bordered within, columellar fold very low, brown.

Length 18.6, diam. 8.8, aperture 7.7 mm.

Length 18, diam. 8, aperture 7.3 mm.

Molokai: Kawela (Baldwin).

Achatinella theodorii BALDWIN, Catalogue etc., 1893, p. 7, (name only).—*Achatinella theodorei* BALDWIN, Proc. A. N. S., Phila., 1895, p. 226, pl. 10, f. 27.—SYKES, Fauna Hawaiiensis p. 330.—*Partulina theodorei* Bald., BORCHERDING, Zoologica xix, p. 65, pl. 4, f. 14, and f. 15, var.

Figured and described from the types. While closely related to *Partulina proxima* by the sculpture and coloration, this species is constantly much narrower, in a considerable series seen. The columellar fold is also less developed. *P. proxima* does not occur in Kawela valley, the type-locality of *theodorei*.

Mr. Sykes placed this species in *Perdicella*, a position approved by Professor Hyatt. Herr Borcherding groups it with *proxima Pse.*, in *Partulina*. It is one of several species connecting *Perdicella* with *Partulina*.

Var. *multistrigata* n.v. (pl. 9, figs. 12, 13, 16) differs by its broader shape and much more numerous, narrow stripes. The types are without exact locality but Borcherding figures a similar shell from Makakupaia. Length 20.5, diam. 11, aperture 9.8 mm.

13. P. MUCIDA (Baldwin). Pl. 9, fig. 17.

Shell sinistral, minutely perforate, solid, ovate-pyramidal, the spire straight-sided, rather acute at apex. First 2 to 4 whorls tawny brown, the last two or three whorls slightly convex, whitish, mottled and banded with flesh color, and having purple brown bands speckled or mottled with white above and below the suture, at the periphery and around the axial perforation. The surface is glossy, with low, rude growth-lines and

faint spiral striation. Aperture small, bluish white within, lip slightly expanded, nearly white and well thickened within. Columellar lamella strong, white with a light brown patch at and above its insertion. Length 21 to 21.2, diam. 11.8, aperture 9.6 to 10 mm.; $6\frac{3}{4}$ to 7 whorls.

Molokai: Makakupaia (Baldwin).

Achatinella mucida BALDWIN, Proc. A. N. S., Phila., 1895, p. 222, pl. 10, f. 23.—SYKES, Fauna, p. 315.—*Partulina mucida* BORCHERDING, Zoologica, xix, p. 73, pl. 6, f. 7, 8.

This small species, described and figured from the types, has a peculiar mildewed or mouldy appearance from having the dark markings overlaid with white. It is very closely related to *A. dwightii*, but differs by its smaller size and details of coloration. No form of dwightii has a dark band along the suture below. The figure represents the same shell figured by Baldwin.

13*a*. Color-var. *macrodon* Borcherding. Pl. 9, figs. 18, 19, 20.

Last embryonic whorl zigzag striped; following whorls white with a faint flesh tint, having distinct purple-brown bands, minutely flecked with white, at suture, periphery and umbilicus. Columellar lamella strongly calloused, projecting horizontally. Length 20 to 22, diam. 11.5 to 12, aperture 9.5 to 10 mm.; whorls $6\frac{3}{4}$ to 7.

Makakupaia (Meyer and others).

Partulina macrodon BORCHERDING, Nachrbl. d. d. Malak. Ges., 1901, p. 56; Zoologica, xix, p. 74, pl. 6, f. 9, 10.

14. P. DWIGHTI (Newcomb). Pl. 8, fig. 1 to 5.

"Shell oblong conical, sinistral, solid, surface covered with longitudinal striæ, cut across by very numerous, fine, slightly undulating cross-striæ. Whorls 6, flatly convex, crenulated at the sutures; suture simple, well marked. Aperture ovate; columella broad, short, and slightly twisted; outer lip expanded, subreflected below. Subumbilicated, color a grayish white, with numerous blotches and zigzag markings of brown, more obscure on the last whorl. Aperture and lip of a dingy white. Length 19, width $9\frac{1}{2}$ twentieths of an inch [about 24 × 12 mm.] (*Newc.*)

Molokai (Newcomb): Makakupaia, Kawela, (fig. 2), Makolelau, Kamalo and Punkaeha, fig. 1, (Meyer); Kamalo (Baldwin).

Achatinella dwightii Newcomb, Ann. Lyc. N. H. of N. Y. vi, p. 145, October, 1855; P. Z. S. 1855, p. 207; American Journal of Conchology ii, p. 213, pl. 19. f. 9.—Pfr., Monogr., iv, p. 517.—Sykes, Fauna Haw. p. 313.—Thwing, Reprint Orig. Descr. Achat. pl. 2. f. 7.—*Partulina d.*, Borcherding, Zoologica xix, p. 68, pl. 5, f. 1–8.

P. dwightii is characterized by the solidity, narrow form with a high, straight-sided, acute spire, and the streaked, mildewed appearance. Typically the last embryonic whorl has protractive stripes and the following whorls of the spire show fleshy-brown mottling or confused zigzag patterns on a pinkish or yellowish-white ground. Last whorl streaked, usually paler below the suture. The surface has rather rude, irregular but low growth-lines, and on the last whorl there are regular, distinct, waved spiral striæ in shells from Newcomb (fig. 5). In most other lots seen the spirals are quite weak or faint. The aperture is small, and the rib is placed rather far within, so that there is an unusually wide whitish lip. The outer edge often expands noticeably. In fully adult shells the columellar lamella is strong and white or nearly so. Some specimens are white with only faint brown streaks and stains, the aperture delicately lilac-tinted, lip white. In others the brown streaks are dark, in part blackish, and nearly cover the last whorl.

Length 26, diam. 15, aperture 13 mm.

Length 25, diam. 13.5, aperture 12 mm.

Length 22, diam. 13, aperture 10.8 mm.

The shape is more straightly pyramidal than in *A. redfieldi*, which also differs by its brown columellar fold and the narrower and brown lip. Its range of patterns is also different.

14*a*. *P. dwightii compta* (Pease). Pl. 8, figs. 6, 7, 8.

Shell sinistral, narrowly perforate, rather solid, oblong-conic; spire obsoletely transversely delicately rugose-striate, the wrinkles disappearing on the last whorl, and longitudinally impressed with delicate, irregular striæ. Spire turrited or oblong-

conic; suture impressed, whorls 6, convex, sometimes subangular above, the last equal to half the length of the shell. Aperture vertical, ovate; columellar fold superior, strong, white; lip slightly expanded, callous within; leaden-gray, encircled with lines or bands of reddish-brown, the last whorl ornamented with a white band at the base. Length 25, diam. 13 mm. (Pease).

Molokai (Pease); Kawela and Makakupaia (Meyer).

Partulina compta Pease, Journ. de Conchyl. xvii, 1869, p. 175; P. Z. S. 1869, p. 647.—Borcherding, Zoologica xix, p. 57, pl. 3, f. 14–16, 18–20.

"This species, which comes from the island of Molokai, is very closely related to *P. splendida* Newc., which lives on Maui. It is more contracted at the base and sometimes has a peculiar angulation of the upper part of the whorls. In coloration it is nearer *P. grisea* Newc." (Pse.).

The ground-color is white or nearly so in the specimens figured by Borcherding and before me in the Academy, Cooke and University of Wisconsin collections. Otherwise they agree well with Pease's description. It would probably be more correct to describe the shell as brown, pale or dark, cut by white bands and lines. It differs from *A. redfieldi* by its white columella and lip. The following race is almost fully connected with *compta* by intermediate specimens, and may perhaps be found to be superfluous. I retain it here because both Borcherding and Hyatt have recognized it, though under different names.

14*b*. *P. dwightii concomitans* Hyatt, n. var. Pl. 8, figs. 9 to 13.

Similar to *dwightii* in the acutely pyramidal contour, solidity, wide white lip, etc.; but it differs by the predominance of chestnut-brown (rarely olive-brown) which forms nearly a solid color on the last two whorls except that there is a subperipheral white belt and sometimes a white line on the upper surface, continuing on the penultimate whorl; the suture has a narrow white edge.

Molokai (A. N. S. P. and Cooke collections): Makakupaia (figs. 9, 10, 12), Kawela (fig. 11) and Makolelau (Meyer).

Partulina grisea Nc., Borcherding, Zoologica xix, p. 69, pl.

5, f. 9–16. Not *Achatinella grisea* Newcomb.—? *Achatinella redfieldi* var. *g*, Sykes, Fauna Hawaiiensis, p. 318, pl. 11, f. 16 (Makakupaia and Kamalo, Perkins).

Borcherding figures a long series of this form, varying from pale brown and gray to deep chestnut, all having a subperipheral white belt. I have not seen gray examples and copy his figure of one (pl. 8, fig. 9). Fig. 13 is the type, no. 106061, A. N. S. P.

While *dwighti* and *concomitans* stand near *grisea* Nc., they differ from it decidedly by the pattern of the early whorls and the stronger columellar lamella. The shell is also larger and more solid than that of *grisea*, which is certainly distinct. We cannot agree with Herr Borcherding that *P. grisea* occurs on Molokai.

15. P. redfieldii (Newcomb.) Pl. 7, fig. 12, 16, 17; pl. 8, figs. 14 to 20.

"Shell sinistral, elongate, conical, striated longitudinally, color light fawn passing into deep chestnut, paler above, plain or with transverse chestnut bands with obscure undulation upon the third whorl only; a white band also traverses the suture, whorls 6; suture well impressed, slightly margined. Aperture subovate; columella brown, flat and twisted; lip slightly reflected, the color of the columella. Length 1, breadth 45 inch (*Newc.*, 1853).

Animal light flesh color, mantle dark slate (*Newc.*, 1854).

"Animal as long as the shell, grayish above, sprinkled slightly with brown, tentacles of same color, mantle slate, bottom of foot of a greenish gray" (Newc., 1858).

Molokai: Mapulehu (Baldwin); Ualapue (Thaanum); Makakupaia and above Kamalo (Perkins); Kamoku, Kawela, Makolelau, Kaluaaha and Ualapue (Meyer).

Achatinella redfieldii Newc., Ann. Lyc. N. H. of N. Y. vi, p. 22, April, 1853; p. 325; P. Z. S. 1853, p. 131, pl. 22, f. 5; 1854, p. 311.—Pfr., Monogr. iv, 523.—Sykes, Fauna Hawaiiensis p. 317, pl. 11, f. 15.—*Partulina redfieldii* Newc., Borcherding, Zoologica xix, p. 71, pl. 6, f. 1–6.

The outlines of the spire are less straightly pyramidal than in

P. dwightii, which is usually more solid, often larger, with a white columella and lip. Newcomb's description of the color-pattern is not quite clear, owing to the failure to place a comma after the word "bands" in his original description, reprinted above. This was rectified by him in the P. Z. S., where in both Latin and English versions he makes it plain that it is only the "undulations" (or axial stripes) which are restricted to the third whorl. Sixteen specimens in coll. A. N. S. P., in two lots received from Newcomb, agree well with his account. Some of them are figured on plate 8, figs. 15 to 18. It will be seen that the color-pattern varies widely. In some specimens the last two whorls are rich brown, uniform or varied with spiral bands and lines, the spire paler above, suture white-edged, lip and columellar fold *brown*. Other shells have a light cream ground on which there are few or many brown spiral lines and bands, or in place of them there may be dark narrow streaks. The last embryonic whorl may have oblique or zigzag stripes, but they are often lacking (pl. 8, figs. 15–18, from shells received from Newcomb). Newcomb's type figure is copied, pl. 8, fig. 14.

Length 25, diam. 14, aperture 13 mm.

Length 21, diam. 13, aperture 10.5 mm.; $6\frac{1}{2}$ whorls.

Length 24.5, diam. 13, aperture 11.3 mm.; $6\frac{1}{2}$ whorls.

There is a continuous intergradation between the dark brown, rich orange-brown and longitudinally lineolate forms, all having a snowy and usually rather broad subsutural band. Often the tawny, longitudinally lineolate form has white or pale brown spiral bands (figs. 15, 16), producing, when the bands become numerous, the pattern shown in Newcomb's figure (copied in pl. 8, fig. 14), which I take to be the typical pattern, though Mr. Sykes has figured one of the dark, bandless shells as typical. It is no great step from some shells of this pattern to *P. dwightii concomitans*.

In the Cooke collection there are white specimens with the lip very pale brown, apical whorls fleshy (pl. 7, fig. 17), with others showing traces of the brown bands on the base and latter part of the last whorl. A peculiar shell has narrow brown lines near suture and on periphery, and a patch at the axis, on a

pale brownish ground, the spire white, becoming fleshy above (pl. 7, fig. 12).

Another form (no. 2068, Cooke coll.) has a snow-white spire and coffee-colored last whorl, aperture pink within, lip brown (pl. 7, fig. 16).

In some examples there is a sutural margin banded by an impressed line, as in *P. proxima schauinslandi*. This is probably a local race.

The color-forms of *A. redfieldii* may be arranged thus:

A.—Uniform dark or light brown with a white sutural border.

Ab.—The same, with darker spiral bands.

a.—Yellowish-brown with narrow streaks of darker brown along growth lines.

ab.—The same cut by white or whitish spiral bands.

b.—White predominating, leaving only traces of dark bands or none.

To what extent these patterns mingle in the same colony is not known to me.

Species of Lanai.

16. P. CRASSA (Newcomb). Pl. 18, figs. 1, 2.

The shell is usually dextral, narrowly umbilicate, acutely ovate-conic, solid, chestnut (the shade varying) with zigzag lines, dots and streaks of a whitish tint, and a white zone below the periphery; spire typically a little attenuated above, the whorls scarcely convex. Surface dull or slightly glossy, closely and rather deeply engraved with spiral lines. Suture scarcely impressed. Aperture ovate, the lip expanded, sometimes almost reflected, white, very strongly thickened within, the callous usually irregular. Columellar lamella obtuse but rather strong. Columellar lip built forward, reflected.

Length 20, diam. 14 mm.; 6⅓ whorls (typical).

Length 18, diam. 13 mm.

Length 19, diam. 12 mm.

Length 22, diam. 14 mm.

Lanai (Newcomb); near Koela (Perkins).

Achatinella crassa NEWC., P. Z. S. 1853, p. 155, pl. 24, f. 71

(1854).—Pfr., Monogr. iv, 527.—Sykes, Fauna Hawaiiensis p. 312.—Thwing, Reprint Orig. Descript. Achat. pl. 2, f. 10.

This very distinct species is more closely related to *P. dwightii concomitans* of Molokai than to any other existing form. In the series of 70 specimens in the collection of the Academy only one is sinistral. There is a good deal of variation in the extent of light markings, but the subperipheral band seems rather constant, being absent in only one example. The dark color varies from chestnut to chocolate, and is more or less streaked with lighter and darker. One specimen (pl. 18, fig. 2) has the whole post-embryonic shell banded as in *P. tessellata*—a notable advance in pattern, foreshadowed by a few others having several basal bands.

The embryonic shell, 5 mm. long, has the first two whorls light fleshy brown, whitish below the suture; some broad, indistinct darker clouds then appear, changing on the last whorl to zigzag axial stripes of dark brown and cream-white ground. The axis is perforate, columella a little convex (pl. 18, figs. 3, 4).

Species of Maui.

The numerous species and varieties fall into three series: that of *P. marmorata*, stout, ovate forms with streaked or striped pattern; series of *P. splendida*, thinner shells with profuse spiral bands and lines; and the series of *P. tappaniana*, mainly light colored, rather narrow forms, uniform, or with spiral bands on a white ground.

Series of P. marmorata.

17. P. kaaeana Baldwin. Pl. 10, figs. 5, 6, 7.

"Shell sinistral, subperforated, solid, globose with a conical spire, apex subacute; surface rather lusterless, covered with rather coarse wavy growth lines, and under a lens exhibiting close and delicate decussating spiral lines; nuclear whorls faintly decussated. Color ashy brown, with a light brown band just below the periphery which enters the aperture; whole surface covered with minute longitudinal white flecks or streaks; apex tessellated white and brown. Whorls 6, not margined above, flatly convex; suture lightly impressed. Aperture a little

oblique, oval, livid white, showing the outside coloring within. Peristome acute, slightly thickened within, expanded, columellar margin reflexed, light brown on both face and the reverse. Columella white, terminating in a strong, plaited, projecting tooth." (*Baldwin*).

Length 21, diam. 13.8 mm.; whorls 6½.

Length 19.8, diam. 13 mm.

"Animal extended in motion longer than the shell. Mantle brownish-black with outer edge bordered with a narrow white line. Foot below and sides light slate color. Head above and tentacles dark slate and granulated" (*Baldwin*).

West Maui; Mt. Helu, 4000 ft. elevation.

Partulina kaaeana BALDWIN, Nautilus xix, p. 113, February, 1906.

A dull brown shell, yellow-banded below the periphery, speckled with whitish flecks, or with the last whorl having only some indistinct flecks and streaks, dark on each side of the light band. Another specimen is reddish brown with many irregular streaks and spots of white, but without the subperipheral light belt. The last embryonic whorl is striped white and brown, as usual. While related to *marmorata*, this is a quite distinct species. Figured from the type lot.

"This shell was found on a mountain peak quite isolated from the main mountain mass of West Maui. We dedicate it to Mr. W. F. Kaae who seems to have been the only one in quest of shells who has ventured to climb this lonely peak. He found the shell in company with *Perdicella ornata* Nc., a species supposed long since to have become extinct," (*Baldwin*).

18. P. MARMORATA (Gould). Pl. 10, figs. 1, 2, 3, 4.

"Shell dextral, rather solid, of an elongated, acutely conical form, composed of 6 convex whorls which are somewhat shouldered superiorly; the last large in proportion, and ventricose. Surface delicately striated with lines of growth. Color a dusky chestnut, marbled with white irregular and angular markings, generally arranged somewhat in longitudinal stripes, the whole seeming to be coated with a very thin, ash-colored epidermis. Aperture moderately large, ovate, the lip slightly

expanded; the columellar fold white, compressed, nearly transverse, and standing out very prominently. Length $\frac{7}{8}$, breadth $\frac{1}{2}$ inch" (Gld.)

East Maui: foot of Mt. Haleakala (U. S. Exped.); Makawao (Baldwin); Kula (Gulick).

Achatinella marmorata Gld., Proc. Bost. Soc. N. H. ii, p. 200, March, 1847; Expedition shells p. 35; U. S. Exploring Exped., Mollusca, p. 85, pl. 7, figs. 94, 94*a*.—Pfr., Monogr. iii, p. 455.—Newcomb, Ann. Lyc. N. H. of N. Y. vi, p. 311. —Thwing, Reprint Orig. Descript. Achat. pl. 2, f. 13.—*Achatinella adamsi* Newcomb, Ann. Lyc. vi, p. 19 (May, 1853). —*A. adamsii* Newcomb, P. Z. S. 1853, p. 137, pl. 22, f. 20.

Perforate, dextral, rather solid, gray-brown, with scattered white spots or irregular stripes dark-bordered on the left side. Last embryonic whorl having wide, strongly protractive white and brown stripes. *Surface dull*, without gloss, by reason of the dense, microscopic, crinkled spiral striæ. Gould's figure is copied, fig. 1.

Length 25, diam. 14.3, aperture 13 mm.; $6\frac{1}{2}$ whorls.

Length 21.2, diam. 13.3, aperture 11.3 mm.; 6 whorls.

Length 21, diam. 12.2, aperture 11 mm.; $6\frac{1}{2}$ whorls.

Newcomb described the animal as "light pea green, strongly granulated, one-third longer than the shell, tentacles light slate; mantle and base of foot same color as the body." He included as synomous: *A. adamsi* Newc., *A. induta* Gul., *A. plumbea* Gul., *A. ustulata* Gul. Mr. Thwing states that "in over one thousand examples only one sinistral specimen was found."

"*A. adamsii.*—Shell dextral, conically acuminate, whorls 6, finely striated transversely, roughly striated longitudinally; suture deeply impressed, lip expanded, columella terminating in a strong, abruptly twisted plait. Interior of shell of a leaden blue color, exterior dark chestnut, irregularly mottled and striped with white. Length 18, diam. 9-twentieths of an inch." *A. adamsii* is terrestrial in its habits.

19. P. plumbea (Gulick). Pl. 10, figs. 8 to 12.

"Shell dextral, sometimes perforate, ovate-conic, solid, shining, irregularly striated, very finely decussated; lead-colored

with a white band on the periphery of the last whorl; apex subacute; spire conical; suture marginate, well impressed. Whorls 6½, very convex. Columellar fold central, white, strong. Aperture slightly oblique, sinuately oval, bluish-white within; peristome brown, thickened within, with dextral margin arcuate, scarcely reflected; columellar margin dilated, white, sometimes slightly detached; parietal margin wanting. Length 23, breadth 13 mm.; length of body-whorl 16½ mm. Average weight 6 grains; least weight 4.3 grains.

Var. *b*. Globose, conic, spire shortened, with concave outlines, body-whorl inflated.

"Var. *c*. Without the white band on the body-whorl" (*Gulick*).

East Maui: Kula, on the trunks of the aiea and kukui. (*E. Bailey*).

Achatinella plumbea GUL., Ann. Lyc. N. H. of N. Y., iv, p. 213, pl. 7, f. 39, 1856.

Very closely related to *marmorata*, perhaps not always distinguishable, but polished, typically belted with white, the band rarely wanting, and without the special marking of *marmorata*. The typical form from Gulick (pl. 10, figs. 9, 10) is usually speckled on the spire with white on a fawn-brown ground. A lot from Baldwin, also from Kula (pl. 10, figs. 11, 12) is drab with darker and lighter streaks, the shell smaller. Another lot from Baldwin, locality not stated, is fawn with narrow brown streaking, with or without a belt, sometimes with some scattered whitish dots (fig. 8).

Large specimens from Gulick measure 25 mm. long, 14.5 wide. The smaller drab form is 22.5 x 12 mm.

20. P. WINNIEI Baldwin. Pl. 13, figs. 1, 2, 3.

Shell sinistral, subperforate, rather thin but moderately strong, long-conic, somewhat glossy. First 1½ or 2 whorls of the embryonic shell flesh-colored, next half whorl boldly marked with broad brown and white axial stripes. Following neanic and adult whorls cream-white, copiously striped with dark chestnut, the stripes more or less irregular and unequal. Growth-lines and spiral sculpture rather weak. A sutural mar-

gin is defined by an impressed line. Aperture flesh-colored within, the lip narrowly thickened, a trifle expanded, white. Columellar fold rather strong, white and oblique.

Length 16.5, diam. 8, aperture 7.8 mm.; whorls 6⅓.

Length 15, diam. 7.8 mm.; whorls 6.

Length 16, diam. 8 mm.

West Maui: Kahakuloa.

Partulina winniei BALDWIN, Nautilus, xxii, p. 67, November, 1908.

"Named in honor of Miss Winnie of Wailuku, Maui." Figured and described from cotypes sent by Mr. Baldwin, who states that it is the counterpart of *Partulina theodorei* Bald. of Molokai. There is a strong resemblance, but I am inclined to think *winniei* a diminutive relative of *P. perdix*. It approaches *Perdicella* in structure of the columella.

21. P. PERDIX (Reeve). Pl. 10, figs. 14, 15, 16; pl. 13, figs. 10 to 13.

"Shell ovate, ventricose, rather thin, dextral, spire exserted, somewhat obtuse at the apex, whorls 6, convex, margined around the upper part, obliquely sculptured with flexuous impressed lines, columella plicately twisted, rather callous, whitish, painted and varigated throughout with olive-brown, sutures and columella white" (*Reeve*).

W. Maui: Lahaina (Baldwin, here selected as type loc.); Olinda at 4000 ft. (Perkins); Honokowai (D. Thaanum).

Achatinella perdix REEVE, Conch. Icon. vi, pl. 6, f. 43 *a*, *b* (May, 1850).—SYKES, Fauna Hawaiiensis p. 315.—BALDWIN, Catalogue p. 7.—THWING, Reprint Orig. Descript. Achat. pl. 2, f. 20.

Achatinella undosa GULICK, Ann. Lyc. N. H. of N. Y., vi p. 205, pl. 7, f. 33, 1856.

The apex (1 to 1½ whorls) is brownish white; the next one or 1½ whorls have broad protractive alternating stripes of snow-white and dark brown. The neanic whorls following have narrow stripes of the same colors, running with the growth-lines. This pattern may continue upon the last whorl, or the stripes may become wider and bisinuate or angular there, with

a streak of darker brown on the left side of each white stripe. In some shells the white is reduced to irregular spots on the last whorl. These patterns are figured. The surface is rather glossy, showing fine spirals under the lens; suture margined with a white cord. Axis imperforate. Length 22, diam. 12½, aperture 10 mm.; 6⅔ whorls.

The shade of brown varies a good deal in different lots. Lahaina specimens are figured, pl. 10, figs. 14 to 16, and pl. 13, fig. 13. In pl. 13, figs. 10, 11, 12, we figure three sinistral specimens from Honokowai, collected by Mr. Thaanum.

Var. *undosa* Gulick (pl. 10, figs. 17, 18, 19). Usually more slender than *perdix*, the spire longer, stripes generally narrow, sometimes pale and linear; distinctly perforate.

Length 22, diam. 11.8, aperture 10.6 mm.; 6½ whorls.

Length 20, diam. 11.9, aperture 10.9 mm.

Length 21, diam. 11, aperture 9.6 mm.

Mountain ridges of Waihee, on the ilima (*Sida*), ki (*Cordyline terminalis*) and other low bushes (E. Bailey).

21*a*. *P. perdix pyramidalis* (Gulick). Pl. 10, fig. 20.

"Shell dextral, very rarely sinistral, imperforate, pyramidal, rather solid, shining; chestnut or ash brown, with a white or yellowish band encircling the base, with oblique white and brown markings on the second and third whorls, bluish-white within the aperture. Apex subacute; spire regularly conical, sometimes decollated. Whorls 6½, convex, margined with white; finely striated transversely, and microscopically decussated with faintly impressed wrinkled spiral lines; the last regularly rounded, equal to 65 hundredths of the length. Columellar fold well developed, white, oblique. Aperture rather oblique, semi-oval; peristome thickened within, very slightly reflected; with columellar margin dilated, adnate or slightly detached; parietal margin wanting.

"Length 21.6, breadth 11.4 mm., aperture 9.66 mm. The dimensions of a large specimen are as follows: Length 23, breadth 12, aperture 10 mm. Average weight 5.7 grains." (*Gulick*).

West Maui: Lahaina, on trees (S. T. Alexander); Huelo (Baldwin); Waihee (Perkins).

Achatinella pyramidata Gul., Ann. Lyc. vi, p. 204, pl. 7. f. 32, 1856.—Baldwin, Catalogue p. 7.—Sykes, Fauna Hawaiiensis p. 317.

Figured from a typical specimen from the Gulick collection, no. 92704 A. N. S. P.

"This shell differs from the *A. splendida* Newc. in its smaller size and pyramidal form, with spire less convex, body-whorl less ventricose, aperture smaller and less oblique, lip less expanded and reflected. It also differs in being without perforation, and is very rarely sinistral.

"The *A. perdix* Reeve differs from this in its broader and more ventricose form, its more convex spire, with whorls more swollen, with aperture broader, and frequently subangulated, the arrangement of colors is also different. Looking only at the type of this species, it would be placed in the same group with *A. splendida*, yet it is so closely connected by intermediate varieties with *A. perdix* that it has hitherto been considered a variety of that species.

"Var. *b*. With black basal band. A small speciman has the following dimensions: length .8, breadth .43, length of aperture .35 inch, weight 4 grains.

"Var. *c*. Without band. I have a small specimen of the brown variety of *A. splendida* which closely resembles this.

"Var. *d*. With apex chestnut-brown, not tessellated; very rare.

"Var. *e*. With irregular white spots. This variety passes into *A. perdix*." (*Gulick*).

22. P. ustulata (Gulick). Pl. 13, figs. 5, 6.

"Shell sinistral, perforate, ovate-conic, obliquely produced at the base, solid, scarcely shining, striated and microscopically distinctly decussated, brown with a whitish band encircling the base. Apex subacute, tessellated with white and brown; spire conical, somewhat curvilinear; suture simple, lightly impressed, marked with a narrow white line; whorls 6½, moderately convex, the last large, equal to 72 hundredths of the length. Columellar fold strong, white, oblique. Aperture very oblique, sinuously oval; peristome thickened within, reflected anteriorly,

with columellar margin dilated, white, unattached; parietal margin wanting. Length 25.4, breadth 14.5, length of aperture 13.2 mm. Weight 10 grains" (*Gulick*).

Maui: Beautiful Valley, on the *mamaki* (S. T. Alexander).

Achatinella ustulata GUL., Ann. Lyc. N. H. of N. Y., vi, p. 211, pl. 7, f. 37, 1856.

"This species is more ventricose than *A. perdix* Rve. and differs in having the whorls more convex, the suture simple, the aperture more oblique and the sculpturing more distinct. I have received but two examples for which I am indebted to the brothers James and Samuel Alexander" (*Gulick*).

Also reported from Lahaina (Baldwin). I have copied Gulick's figure (pl. 13, fig. 6), and add another (fig. 5) representing a shell from the Gulick collection from Kahoma, W. Maui. It has two light bands on the last whorl, and the spiral sculpture is very weak.

23. P. INDUTA (Gulick). Pl. 13, fig. 7.

Shell dextral, perforate, ovate-conic, solid, unpolished, microscopically very minutely and obsoletely decussated, brown. Apex subacute, tessellated with white and chestnut; spire convexly conical; suture lightly impressed, not margined. Whorls 6, slightly convex, the last equal to 66 to 72 hundredths of the whole length. Columellar fold strong, white, nearly transverse. Aperture slightly oblique, sinuously oval, bluish-white within; peristome thickened within, with anterior margin slightly reflected. Columellar margin dilated, white, unattached; parietal margin very thin or wanting. Length 21, breadth $12\frac{2}{3}$, length of aperture 10 mm. Average weight 6.7 grains" (*Gulick*).

West Maui: mountain ridges of Wailuku, on the ilima (*Sida*) and other bushes (E. Bailey).

Achatinella induta GULICK, Ann. Lyc., vi, p. 207, pl. 7, f. 34*a*, 34*e*, 1856.—BALDWIN, Catalogue, p. 6.

"This species is characterized by its unpolished brown exterior" (*Gulick*). It has a close resemblance to the East Mauian *marmorata* Gld., and is very near *ustulata* Gul. *A. perdix* and *undosa* differ by their polish and more definite color-patterns. Figured from specimens of the Gulick collection, no.

92712 A. N. S. P. Another lot from Waihee is similar, but contains some individuals marked somewhat like *marmorata*.

"Var. *b*. Ash-brown with whitish streaks and spots. This variety passes into *A. undosa*.

"Var. *c*. With a white band on the periphery of the last whorl; very rare.

"Var. *d*. Small, ovate-conic. The dimensions of one of the smallest specimens are as follows: length 18, breadth 10, length of aperture $8\frac{2}{3}$ mm. Weight 4 grains.

"Var. *e*. Lip considerably expanded and reflected, slightly thickened within; columella broadly reflected. This variety presents a remarkable feature; appearing as if the body-whorl had been enlarged and the lip expanded by a second growth after the shell has been perfected and the lip thickened. The second growth forms a broad lip sometimes an eighth of an inch or more in width from the interior callous ridge to the edge. This lip seem to be of the same material as the thickening within, the exterior being of an unpolished ivory color, not covered with the brown coat which clothes the rest of the shell. The interior of both the lip and columella is of polished ivory white; aperture within the lip bluish white. Specimens presenting more or less of the features of this variety are not rare" (*Gulick*).

24. P. RADIATA (Gould). Pl. 13, figs. 8, 9.

Shell solid, ovate-conic, longitudinally painted with chestnut, yellow and whitish lines, sometimes girdled with a median or basal white band; subumbilicate; whorls 6, convex, the suture margined, whitish; aperture ovate, peristome reflexed, yellow; fold broad. Length $\frac{3}{4}$, diam. 9-twentieths inch. In size and markings it resembles *Bul. radiatus*, but the lines are finer and more numerous (*Gld.*).

Sandwich Islands (Gld.).

Achatinella radiata GLD., Proc. Boston Soc. N. H., 1845, p. 27; Otia Conch., p. 195.—PFR., Monogr., iii, 454; iv, 517; vi, 162.—*Bulimus gouldi* PFR., Zeitschr. f. Malak., 1846, p. 116; Monogr., ii, p. 74.—*Partula densilineata* REEVE, Conch. Icon., vi, pl. 2, fig. 9, April, 1850.

The locality of this species is not known; *radiata* and *gouldi* were stated to be from the Sandwich Islands, and for *densilineata* no habitat was known. It is not even certain that the three names pertain to one species, though I think that they do. Gould's white-banded specimens were probably different. The original descriptions are given below.

I believe that Newcomb correctly identified *radiatus* but unfortunately the specimens from him in our collection bear no locality. Two of them are illustrated in pl. 13, figs. 8, 9. The shell is distinctly perforate, ovate, with rather straight-sided spire. Spiral striation weak, very faint on the last whorl, whorls weakly convex, the last convex; the suture usually marked with a white line. Embryonic whorls uniform pale brown but darker at the tip; later whorls closely streaked with narrow streaks or lines of brown, cream and whitish. Lip slightly expanded, more so below, whitish, calloused within. Columellar fold rather sharp but not prominent.

Length 18, diam. 11.3, aperture 9.8 mm.; $6\frac{1}{4}$ whorls.

Length 18, diam. 10.5 mm.

One of the lot has the brown replaced by olivaceous, and another has faint traces of several spiral lines on the base.

While the absence of flammules on the last embryonic whorl is anomalous, yet the species has the appearance of a Maui shell.

Bulimus gouldi Pfr. Shell narrowly umbilicate, ovate-conic, rather solid, very delicately decussate-striatulate, glossy, elegantly radiated with ashen, brown and white. Spire conic, rather acute. Whorls 6, a little convex, the last about three-sevenths the total length. Columella twisted plicate, white. Aperture oblong, white within. Peristome narrowly expanded, the margins subparallel, columellar margin broadly reflexed, not covering the umbilicus. Length 19, diam. 10, aperture 9 mm. long, 5 wide within. Sandwich Islands, Mus. Cuming (*Pfr.*)

Partula densilineata Reeve (pl. 13, fig. 4). "Shell acuminately conical, rather thin, umbilicated, sutures of the spire impressed, whorls rather flattened and finely margined around the upper part, rounded and slightly angled at the lower, colu-

mella flatly reflected, obsoletely plicate, aperture ovate, lip but little reflected; whitish, very thickly painted with oblique rust and ash lines. Hab. ——? The lip of this shell, the only example of the species known to me, is scarcely mature. The linear painting is discontinued before reaching the umbilicus" (*Rve.*)

Series of P. splendida.

25. P. SPLENDIDA (Newcomb). Pl. 11, figs. 1 to 10.

"Shell sinistral, solid, ovate-acuminate, finely decussately striated; suture moderately impressed, margined. Whorls 6; body whorl somewhat inflated. Aperture ovate; lip expanded; columella short, broad and twisted. The upper two whorls tessellated with chestnut and white, lower whorls with numerous chestnut-colored transverse lines and fillets traced on a polished white ground, markings correctly lined superiorly and irregularly serrated inferiorly. Length 1, diam. .55 inch" (*Newc.*).

West Maui: Wailuku, on tutui trees (Newcomb); Mauna Hoomaha (Thaanum); Lahaina, Wailuku and Wailee (Gulick).

Achatinella splendida NEWC., Ann. Lyc. N. H. of N. Y. vi, p. 20, April, 1853; P. Z. S., London, 1853, p. 131, pl. 22, f. 4; Ann. Lyc. N. H. of N. Y. vi, p. 324.—PFR., Monogr. iv, 516. —THWING, Reprint Orig. Descript. Achat., pl. 2, f. 17.—*Achatinella solida* Gulick, MS. according to PFEIFFER, Monographia iv, 516.—*Achatinella baileyana* GULICK, Ann. Lyc. N. H. vi, p. 202, pl. 7, f. 31*a*, *b* (Dec. 1856).

The embryonic shell consists of 3 to 3½ whorls, the first 1 or 1½ flesh-tinted, wide, indistinct dark stripes then appearing. The last embryonic whorl has alternately snow-white and brown stripes, very obliquely descending forwardly. The banded pattern then begins. The lines and bands of brown are usually a little serrate. The surface is glossy, with dense, weakly developed decurrent striæ. Banding variable, as shown in the figures, in all the localities mentioned above.

In a lot of 42 from Wailuku, 24 are sinistral. A lot of 32 from Wailee has 7 sinistral, all with broad bands. From Lahaina, in a lot of 60 shells, 34 are sinistral, patterns the same as in the dextral shells. Specimens from Wailuku are figured,

figs. 1 to 9. Fig. 10 is from Lahaina. Wailuku specimens measure:

Length 25½, diam. 15 aperture 12½ mm.

Length 25½, diam. 13.8 aperture 11.2 mm.

Length 24, diam. 15 aperture 12 mm.

Length 22, diam. 12.5 aperture 10 mm.

Var. *baileyana* (Gulick). Pl. 11, figs. 11, 12, 13. The shell is sinistral, perforate, white with few or many narrow deep brown spiral lines, sometimes with a broad belt of pale brown under the lines; otherwise as in *splendida*. Length 21.6, diam. 12.4, aperture 10 mm. weight 7 grains, or larger, length 25.4, diam. 13.5, aperture 11.4 mm. Wailuku mountain, on trees, Ed. Bailey Jr. Gulick describes three varieties as follows:

"Var. *b*. Regularly conical, rather broad at the base, with spire shortened. Whorls nearly 7, convex, not margined. Aperture very oblique, semiorbicular, pale blue within. Length 17, breadth 13, length of aperture 8⅔ mm. Weight 6 grains.

"Var. *c*. Ovate-conic, marble gray, bands usually wanting; within the aperture pale lilac; whorls somewhat swollen beneath the sutures; columella not so short. This variety passes into the white variety of *A. splendida* Newc.

"Var. *d*. Lightly tinged with pink both within and without."

26. P. GOULDII (Newcomb). Pl. 11, figs. 14, 15, 16.

Shell dextral, conically ovate, longitudinally striate; suture moderate, not margined or but slightly so; whorls 6, flatly convex, color yellowish-white with zigzag lines of brown on the third whorl, and brown lineations more or less numerous encircling the three lower whorls. Aperture rounded ovate, yellowish; columella lightly callous; lip expanded and below reflected. Length .85, breadth .45 inch (*Newc.*).

West Maui: Wailuku valley, on tutui trees (Newcomb).

Achatinella gouldii NEWC., Ann. Lyc. N. H. of N. Y., vi, p. 21, April, 1853; P. Z. S., 1853, p. 129, pl. 22, f. 1, 1854.—PFR., Monogr., iv, 517.—*A. myrrhea* Gul., according to Pfeiffer, *l. c.*, undescribed.—*Achatinella talpina* GULICK, Ann. Lyc., vi, p. 212, pl. 7, f. 38, 1856.

This species resembles *P. splendida* Nc. in color-pattern, but

it is smaller, with less convex whorls, the last one shorter. So far as we know it is always dextral. Perforation small, sometimes closed. In the typical form the bands, of a light brown color, are more or less distinctly spotted with darker; and when the bands spread to cover most of the surface, they are marked with dark streaks. The last embryonic whorl has oblique stripes as in related species, and the first neanic whorl is irregularly clouded and streaked. The columellar fold is low and oblique, white. Lip distinctly but narrowly thickened within, white, outwardly a little expanded.

Length 21, diam. 12, aperture 10 mm.; $6\frac{1}{3}$ whorls.

Length 20, diam. 11 mm.

A. talpina Gul. has always been considered synonymous with *gouldii*. It is here figured (pl. 11, fig. 17) from a specimen from Gulick. Although Gulick mentions only one band, his figure and specimens show numerous lines also. The columellar fold is slightly stronger and less oblique than in typical *gouldii*. The original account follows:

"*Achatinella talpina*, shell dextral, slightly perforate, elongate ovate-conic, rather thin, subcorneous, not shining, finely striated, beneath the lens scarcely decussated; brown with a whitish band encircling the base, covered with a thin, brown ash, velvety epidermis. Apex somewhat obtuse, tessellated with white and chestnut; spire regularly conical; suture simple, moderately impressed, whorls nearly 7, convex, the last regularly rounded, equal to 62 to 76 hundredths of the length. Columella strongly plaited above. Aperture semi-orbicular, brownish-white within; peristome thickened within, scarcely reflected anteriorly, with columellar margin white and reflected over the deep perforation; parietal margin wanting. Length 21.6, breadth 12, length of aperture 9 mm.; weight 5.5 grains.

"Var. *b*. With apex corneous, without tessellations; very rare.

"Var. *c*. Ventricose; spire short, curvilinear. A small specimen has the following dimensions: length 17, breadth $10\frac{2}{3}$, length of aperture $7\frac{2}{3}$ mm., Weight 4.5 grains."

Maui: Wailuku, on the kukui, *Aleuritis triloba*, rare, E. Bailey Jr.

"This species passes into *A. gouldii* Newc. Much handling gradually removes the epidermis from the shell, leaving the surface more or less polished" (*Gulick*).

26*a*. *P. gouldi perfecta* n. var. Pl. 11, figs. 18 to 21.

The bands are very dark chestnut on a cream-white ground. The lip has a stronger callous rib within and is slightly flesh-tinted, with faintly traced bands. The columellar fold is twisted, very strongly projecting, subhorizontal; axis perforate or closed. Color-pattern various, as figured.

Length 20, diam. 12, aperture 9.8 mm.; $6\frac{3}{4}$ whorls.

Length 19.5, diam. 11 mm.

Wailuku (D. D. Baldwin). A small form or race from the same valley (pl. 11, figs. 20, 21) measures, length 17, diam. 10 mm.; $6\frac{1}{2}$ whorls.

27. P. APTYCHA (Pfeiffer). Pl. 18, fig. 5.

Shell imperforate, dextral, oblong-conic, rather thin, striatulate, a little shining; white, ornamented with dotted chestnut girdles. Spire long-conic, the apex rather obtuse, suture nearly simple. Whorls $6\frac{1}{2}$, a little convex, the last nearly equal to two-fifths the total length, rotund at base. Aperture oblique, truncate-oval, milk-white within. Columellar fold obsolete, very slightly twisted. Peristome simple, very lightly thickened within, the right margin unexpanded, columellar margin narrow, adnate. Length $21\frac{1}{2}$, diam. 10 mm., aperture $9\frac{1}{2}$ x $5\frac{1}{2}$ mm.

Sandwich Islands (Frick in Cuming coll.).

Achatinella aptycha PFR., P. Z. S., March, 1855, p. 1, pl. 30, f. 1; Monographia, iv, 562; Nomenclator Hel. Viv., 1881, p. 315 (*Perdicella*).

A "lost" species, unknown to Hawaiian collectors. It seems as near a young *gouldii* or *baileyana* as anything. Sykes remarks "probably from Maui."

Series of P. tappaniana.

28. P. TAPPANIANA (C. B. Adams). Pl. 12, figs. 1, 2, 3.

"Shell reversed, elongate ovate-conic; pure white, with one

narrow brown spiral band on the periphery of the last whorl; with very unequal and irregular transverse striæ and numerous excessively minute, wrinkled spiral impressed lines. Apex subacute; spire elongate, with the outlines a little curvilinear. Whorls nearly 7, moderately convex and more or less subangular, margined above, with a well-impressed suture. Aperture ovate; lip well thickened within the margin, expanded much anteriorly, but not above; columellar fold strong. Mean divergence 43 degrees. Length 1.06, breadth .55 inch; length of aperture .44 inch. Length 26½, diam. 13¾, aperture 11 mm.

"Var. *dubiosa* differs in being a little more ventricose; its whorls are not margined above, and the brown stripe is replaced by two fine paler brown lines, below which one or two other yet finer lines may be seen.

"Sandwich Islands.

"This beautiful species is named in honor of Hon. Benjamin Tappan, of Ohio." (*C. B. Ad.*)

W. Maui: Wailuku (Gulick); Lahaina (Gulick, Baldwin).

Achatinella tappaniana C. B. Ad., Ann. Lyc. N. H. of N. Y., v, p. 42, 1851; Contrib. to Conch., no. 8, p. 126.—Pfr., Monogr., iii, p. 462.—Sykes, Fauna Hawaiiensis, p. 318.—Baldwin, Catalogue, p. 7, 1893.—Thwing, Reprint Orig. Descript. Achat., pl. 2, f. 19.

This well-known shell has a long, noticeably concave-sided spire, margined suture, and one narrow brown band just below the periphery, so that it enters the aperture below the insertion of the outer lip. There are 3½ embryonic whorls, of a whitish tint, the last half whorl in young or very fresh examples usually showing protractive yellowish stripes. Young shells are covered with a yellow cuticle which is deciduous, disappearing in the adult stage. The surface is rather dull, under the lens showing spiral impressed lines and weak decurrent striation. The young and half grown shells are rather acutely angular at the periphery in front of the aperture. Wailuku is here selected as the type locality (pl. 12, fig. 1). Length 24, diam. 12 mm.; 7 whorls.

Kahoma specimens are somewhat stouter, length 25, diam. 14 mm.; 6½ whorls. They have one band or none, and one

specimen shows faint traces near the lip of numerous other bands, thus approaching var. *fasciata*.

In a series from Lahaina the shell is pure white at all stages of growth, or there may be some faintly sketched yellowish spiral lines below the periphery, which is acutely angular in front in the young. The fine descending striæ are more distinct in most specimens (pl. 12, figs. 2, 3).

28*a*. *P. tappaniana fasciata* (Gulick). Pl. 12, figs. 5, 6, 7.

Shell sinistral, sometimes perforate, ovate-conic, solid, shining, finely striated, microscopically very minutely and faintly decussated, white, with brown bands; apex subacute, white, with a brown line above the suture; spire regularly conical; whorls 6 or 7, convex, not margined; the last rounded, equal to $\frac{65}{100}$ of the length; columellar fold white, superior, slightly developed, moderately twisted; aperture somewhat oblique, roundly oval, white within; the bands sometimes appear in pale brownish stripes in the inner surface; peristome white, slightly thickened, subreflected anteriorly; with columellar margin reflected, scarcely adnate; parietal margin wanting. Average length 22; greatest length 25; broadest $11\frac{1}{2}$; length of aperture 10 mm. Average weight 6.8 grains; greatest weight 9 grains; least weight 6 grains. (*Gulick.*)

Maui: Honukawai, on the wiliwili (*Erythrina monosperma*), S. T. Alexander.

Var. *b*. Thicker and more elongate, with dark brown or black bands; lip well thickened within, and deeply colored on the edge opposite the bands; columella slightly toothed.

Var. *c*. Ventricose, conical; one specimen has the following dimensions: Length 0.86; breadth 0.54; length of aperture 0.40 inch.

Remarks.—Has been confounded with *A. tappaniana* and *A. splendida* Newc., but is smaller than the former, with fainter sculpturing and more regularly conical spire; it also differs in its dark bands, rounded body whorl, less reflected lip, and slight columellar fold. It resembles *A. splendida* Newc. in its brown bands, but is otherwise quite distinct. A nuclear character which distinguishes it from either of the above is the spiral line on the first whorls. (*Gulick.*)

Achatinella fasciata Gul., Ann. Lyc. vi, p. 201, pl. 7, f. 30, 1856.

Figured from Honokawai shells of the Gulick collection. Hardly distinguishable from var. *ampulla;* I think them extremes of one variety. The figures are from topotypes from Gulick. The same form is in the Gulick collection from Wailuku.

28*b*. *P. tappaniana ampulla* (Gulick). Pl. 12, fig. 4.

"Shell sinistral, sometimes slightly perforate, elongate, subpyriform, rather thin, shining, finely striate, scarcely decussate beneath the lens, white, with a broad chestnut band encircling the base, and revolving within the shell beneath the suture, sometimes with fine spiral lines above; apex subacute; spire concavely conical, sometimes decollated; whorls $6\frac{1}{2}$, convex, margined above; the last inflated, equal to $\frac{66}{100}$ of the length; columella white, plaited near the whorl, strongly twisted, not tuberculate; aperture rounded; peristome expanded, reflected, very slightly thickened; with columellar margin reflected, adnate or slightly detached; parietal margin wanting. Length 23; breadth 13; length of aperture 10 mm. Weight 6 grains" (*Gulick*).

Maui: Honukawai, on trees, S. T. Alexander.

Achatinella ampulla Gulick, Ann. Lyc. vi, 200, pl. 7, f. 29.

"This species differs from *A. fasciata* Nob., to which it is closely allied, in the concave outlines of the spire, in its inflated body whorl, and more expanded and reflected lip" (*Gulick*).

28*c*. *P. tappaniana eburnea* (Gulick). Pl. 12, figs. 9, 10, 11, 12.

"Shell sinistral, usually perforate, ovate-conic, somewhat solid, shining, striated, very minutely decussated, ivory-white; apex rather acute; spire concavely conical; suture slightly margined, lightly impressed; whorls 6, slightly convex; the last large, obliquely produced, and angulated above the aperture; columellar fold central, white, strong, nearly transverse; aperture oblique, truncately auriform, white within; peristome thickened; with external margin reflected, anteriorly arcuate; columellar margin dilated, slightly detached; parietal margin wanting. Length 24; breadth 14; length of body whorl 17 mm. Average weight 9 grains; greatest weight 13 grains" (*Gulick*).

East Maui: Honuaula, on the trunks of trees, quite exposed, E. Bailey.

"Var. *b*. Brownish-yellow, with a white girdle on the periphery of the last whorl, waved with white and yellow on the third whorl.

"Var. *c*. With body whorl rounded, not angulated. This species is the analogue of *A. tappaniana* C. B. Ad. found on W. Maui, but differs from it in its more ventricose form, its angulated body whorl, and more regularly curved lip, besides the difference in color" (*Gulick*).

Achatinella eburnea GULICK. Ann. Lyc. N. H. of N. Y. vi, p. 199, pl. 6, f. 28*a*, *b*. 1856.—BALDWIN, Catalogue, p. 6 (Makawao).—THWING, Reprint, pl. 2, f. 14.

I cannot distinguish the typical form of *eburnea* (pl. 12, figs. 9, 10) from the pure white West-Mauian form of *tappaniana*. The Var. *b* (pl. 12, figs. 11, 12) however is unlike any West-Mauian form I have seen, and approaches very close to *carnicolor* Baldwin. I doubt whether a specific line can be drawn between them.

29. P. CARNICOLOR Baldwin. Pl. 12, figs. 13, 14.

"Shell dextral, minutely perforated, solid, acuminately ovate conic, apex subacute; surface lusterless, marked with delicate incremental striæ, and under a lens exhibiting a fine pattern of decussating spiral striæ; nuclear whorls faintly decussated. Of a uniform brown color, with a narrow white line below the periphery which enters the aperture, and a very narrow white line traversing the suture. Whorls 6, slightly marginate above, a little convex; suture lightly impressed. Aperture oblique; oval, livid white, showing the exterior coloring within. Peristome acute, expanded, columellar margin broadly reflexed. Columella white, terminating in a well developed, flexuous fold. Length 25, diam. 14 mm." (*Baldwin*).

East Maui: Nahiku.

Partulina carnicolor BALDWIN, Nautilus xix, February, 1906, p. 112.

In sculpture this form agrees with *eburnea* Gulick. It is

fleshy brown, darkest at the base, the aperture flesh-colored within. The band below the periphery is sometimes very narrow—less than 1 mm. wide. I think it doubtfully distinct from the var. *b* of *eburnea*. Figured from cotypes.

30. P. NIVEA (Baldwin). Pl. 12, fig. 8.

The shell is sinistral, subperforate, acutely conic, thin but moderately strong, glossy, snow-white with a brownish-yellow band below the periphery. Growth-striæ distinct but fine and irregular; spiral striation almost effaced on the last whorl, more distinct above. The spire is a little attenuated near the acute apex; whorls but slightly convex, the suture not deep, margined below. Last whorl a little swollen just below the suture, then flattened, often having a peripheral angle weakly sketched in front of the aperture; periphery very convex; base not very convex. The aperture is oblique, white within, with a rather strong rib within the lip, which is a little expanded. Columellar lamella white, rather strong and oblique.

Length 24, diam. 14 mm.; 6½ whorls.

Length 23, diam. 12 mm.; 6½ whorls.

"Animal when extended in motion longer than the shell. Mantle densely black, with minute brown flecks and a broad yellowish band encircling the outer edge. Tentacles and superior portion of foot brown with a slight slate tinge. Under portion of foot light brown. Front above covered with light granulation" (*Baldwin*).

East Maui: Makawao to Huelo (Baldwin).

Achatinella nivea BALDWIN, Proc. A. N. S. Phila., 1895, p. 222, pl. 10, f. 19.—THWING, Reprint Orig. Descript. Achat., pl. 2, f. 16.

"I have before me over 500 examples of this species, which are without variety in color or shape" (*Baldwin*). It differs from *tappaniana* by the more acute apex, less attenuated spire, flatter whorls, the last having its greatest convexity lower down, and by the more glossy surface. In *A. dolei* the upper part of the last whorl is much more convex, and the color differs. Described from the type lot, no. 65691 A. N. S. P. Several other lots seen agree exactly with this one.

30*a*. Var. *kaupakaluana* n. v., pl. 13, fig. 16, has the last $2\frac{1}{2}$ whorls closely streaked with ochraceous or olive-buff on a whitish ground, a white belt on the base. It is known to us by two examples, not quite mature, from Kaupakalua, no. 2101 coll. C. M. Cooke.

31. P. DOLEI (Baldwin). Pl. 12, figs. 15 to 18.

Shell sinistral, perforate, acutely pyramidal, thin but strong, glossy, white with a dark chestnut band below the periphery, and usually several lines and obliquely-streaked bands of light brown in the peripheral region. Surface polished, delicately marked with growth-striæ and almost effaced spiral lines. Spire straightly pyramidal, rather acute, the apex white. Post-embryonic whorls decidedly convex, the last swollen below the suture, then somewhat compressed; suture deep, narrowly margined. The aperture is oblique, white within, with a rib within the lip, which expands somewhat. Columellar fold strong and oblique.

Length $24\frac{1}{2}$, diam. 14 mm.; $6\frac{3}{4}$ whorls.

Length 25, diam. 15 mm.

Length $25\frac{1}{3}$, diam. 14 mm.

"Animal when extended in motion longer than the shell. Mantle intensely black with a broad outer margin of yellow and a conspicuous orange spot in the center of the margin. Foot tapering behind, above and below light yellow. Tentacles long and slender, light slate. Head above lightly granulated" (*Baldwin*).

East Maui: Honomanu, very abundant in humid forests of the exterior slope of Haleakala crater, 7000 feet above sea level (*Baldwin*).

Achatinella dolei BALDWIN, Proc. A. N. S. Phila., 1895, p. 221, pl. 10, f. 17, 18.

The dark band below the periphery is a constant feature, and rarely no other markings are present. When lighter bands are developed they may ascend the spire above the suture, or they may be confined to the last whorl. The embryonic shell (pl. 15, fig. 18) is acutely angular and has a subperipheral band. The columella is convex. It is closely related to *P. nivea* but

differs by the swollen upper part of the last whorl and the coloration. *P. splendida* Newc. of West Maui has a differently shaped last whorl. Figures 15–18 are from cotypes. Named in honor of the President of the Republic of Hawaii, Hon. S. B. Dole.

32. P. LEMMONI Baldwin. Pl. 12, figs. 19, 20.

The shell is sinistral, imperforate, pyramidal, ivory-white variously marked with dark chestnut bands, which are darker, chocolate, at the base, broad band at and below the periphery, another around the columella constant; suture bordered with a white line, dark bands above and below it, the embryonic shell white. Surface glossy, finely striate with growth-lines and fine, weak spirals. Outlines of spire nearly straight, last two whorls convex. Aperture oblique, blue-banded within on a white ground. Lip a trifle expanded, thickened within, spotted by the bands. Columellar fold rather strong.

Length 23, diam. 12.5, length aperture 10 mm. $6\frac{1}{2}$ whorls.

Length 20, diam. 11.7 mm., whorls $6\frac{1}{5}$.

"Animal in motion as long as the shell. Mantle brownish black, mottled with white streaks, with a broad yellowish brown border somewhat interrupted. Foot above and below very light brown. Tentacles slate color" (*Baldwin*).

East Maui: Nahiku (N. E. Lemmon).

Partulina lemmoni BALDWIN, Nautilus xix, p. 112.

This quite distinct species is related to *eburnea*, *dolei* and the smaller *flemingi*, in which however the bands extend upon the embryonic shell. Figures and description from cotypes.

33. P. TEREBRA (Newcomb). Pl. 15, figs. 1 to 9.

"Shell turrited; whorls 6, rounded, last one inflated, margined above; suture well impressed. Aperture elongate-ovate; lip slightly reflected, thickened within. Columella short, terminating in a prominent, twisted plait. Striæ decussating. Color light yellow, with wave-like brown-colored markings, nearly obsolete on the upper whorls; lip, columella and aperture white. Length $\frac{16}{20}$, diam. $\frac{6}{20}$ inch" (*Newc.*).

West Maui (Newcomb); Honokowai (Baldwin).

Achatinella terebra Newc., P. Z. S., 1853, p. 144, pl. 23, f. 40.—Pfr., Monographia iv, 525; vi, 168.—Thwing, Reprint, pl. 2, f. 18.—*A. corusca* Gulick and *A. perforata* Gulick, undescribed, Pfr., Monogr. iv, 525 (names only).—*Achatinella attenuata* Pfr., P. Z. S., 1855, p. 4, pl. 30, f. 12.—*Achatinella lignaria* Gulick, Ann. Lyc., p. 209, pl. 7, f. 35, 1856.

Newcomb's original figure is copied, pl. 15, fig. 2. A specimen received from Dr. Newcomb, typical in markings though somewhat smaller, is drawn in pl. 15, fig. 1. The last embryonic whorl has rather wide stripes, the following whorls narrow, more or less angulated in places, and of a tawny color on a white ground. The surface is glossy and the spiral and decurrent striation weak. Length 18, diam. 9.5 mm., of fully 6 whorls.

Besides this typical form, Newcomb sent out *lignaria*, *corusca* and *longior* as *terebra*. It will probably be possible for a naturalist in the field to arrive at some trustworthy conclusion as to the rank or value of the several named forms of this group. Without such knowledge, I must be satisfied to give the data relative to the various forms.

In a series from Waiehu (pl. 15, figs. 4 to 8) from Baldwin the shell is stouter than Pfeiffer's figure of *attenuata*, and the stripes are less flexuous. Surface glossy. They vary from pure white, through faintly striped to copiously striped forms, the latter usually having the ground of a pale brown tint. The shape also varies. Length 16 to 18 mm. The white examples are not distinguishable from the following variety.

Var. *corusca* Gulick. Pl. 15, fig. 9. Gulick referred specimens from Wailuku (which intergrade with *lignaria*) and from Waihee, to *attenuata*. His undescribed *A. corusca*, according to unlocalized specimens before me, agree well with the Waihee lot, and were probably from that place. The name was afterwards abandoned by Gulick, who adopted *attenuata* in its place. The shells are white, rather glossy, often with some faint bluish stripes on the last embryonic whorl. The sutural margination is conspicuous. Spiral sculpture visible throughout but rather weak. Length 16.3, diam. 8.5 mm. to length 18, diam. 9 mm.

The Wailuku lot consists partly of shells like those from

Waihee, partly of more swollen shells, with more or less straw or brownish tint. One of the white shells has dark bands at periphery and columella. On another there are very faint tawny stripes.

33*a* *P. t. attenuata* (Pfeiffer). Pl. 15, fig. 3.

Shell subperforate, ovate-turrited, rather thin, striatulate and under a lens granulate, white, painted with corneous streaks which are often angular. Spire concavely turrited, the apex rather obtuse, suture distinctly thread-margined, whorls 5½, the upper flat, those following convex, last whorl about three-sevenths the total length, rounded, base subcompressed. Aperture oblique, subtetragonal-auriform; columellar fold strong, compressed, tongue-shaped; peristome acute, narrowly expanded, labiate within, basal margin forming an angle within with the dilated columellar margin. Length 16, diam. 7½ mm., aperture with peristome 7½ mm. long, 4 wide. Maui, Frick (*Pfr*).

The type figure is copied, pl. 15, fig. 3. The smaller size and narrower form distinguish it from *terebra* and *lignaria*. Type locality unknown.

33*b*. Var. *longior* n. v. (pl. 15, fig. 12). Straightly pyramidal, whitish with a pale yellow tint, the last embryonic whorl generally having faint stripes, and under a lens very faint yellow streaks may often be seen on the last whorl. Surface with but little gloss, and usually deeper spiral sculpture than in the smaller var. *corusca*.

Length 22, diam. 10½ mm. 6¾ whorls.

Length 22, diam. 10 mm. 7½ whorls.

Wailuku (Gulick); also Waiehu (Baldwin).

33*c*. *P. t. lignaria* (Gulick). Pl. 15, figs. 13 to 17.

"Shell dextral, perforate, ovate-conic, solid, more or less shining, microscopically minutely decussated, yellowish ivory-white, sometimes streaked; apex subacute, white, obliquely marked with brownish-yellow; spire regularly conical, suture moderately impressed, scarcely margined; whorls 6½, somewhat

convex; the last equal to $\frac{66}{100}$ of the length; columellar fold strong, white; aperture somewhat oblique, sinuously oval; peristome thickened, sometimes slightly expanded and reflected anteriorly; columellar margin dilated, white, unattached; parietal margin wanting. Length $20\frac{1}{3}$; breadth $10\frac{2}{5}$; length of aperture 9 mm. Average weight 5.5 grains" (*Gulick*).

West Maui: Wailuku, on the alii and other low trees, in damp, elevated regions. E. Bailey.

"This species differs from *A. induta* Nob. in its smaller size, more acuminate form, lighter color, and in the polished exterior of some of its varieties.

"Var. *b*. More ventricose; aperture nearly semiorbicular. This variety passes into *A. induta*.

"Var. *c*. More elongate. Length $19\frac{1}{3}$; breadth 9; length of aperture 8 mm.; average weight 3.50 grains. This variety approaches and passes into *A. terebra* Newc. The two species are, however, distinctly characterized; the latter being more strongly sculptured, having the aperture more elongately oval, and the suture more distinctly margined.

"Var. *d*. With black or brown spiral bands. This passes into *A. splendida* Newc., but is distinguished by its smaller size and stronger columellar fold. Rather rare.

"Var. *e*. White. This passes into *A. attenuata* Pf.

"Var. *f*. Pale ash-color. Passes into *A. undosa* Nob.

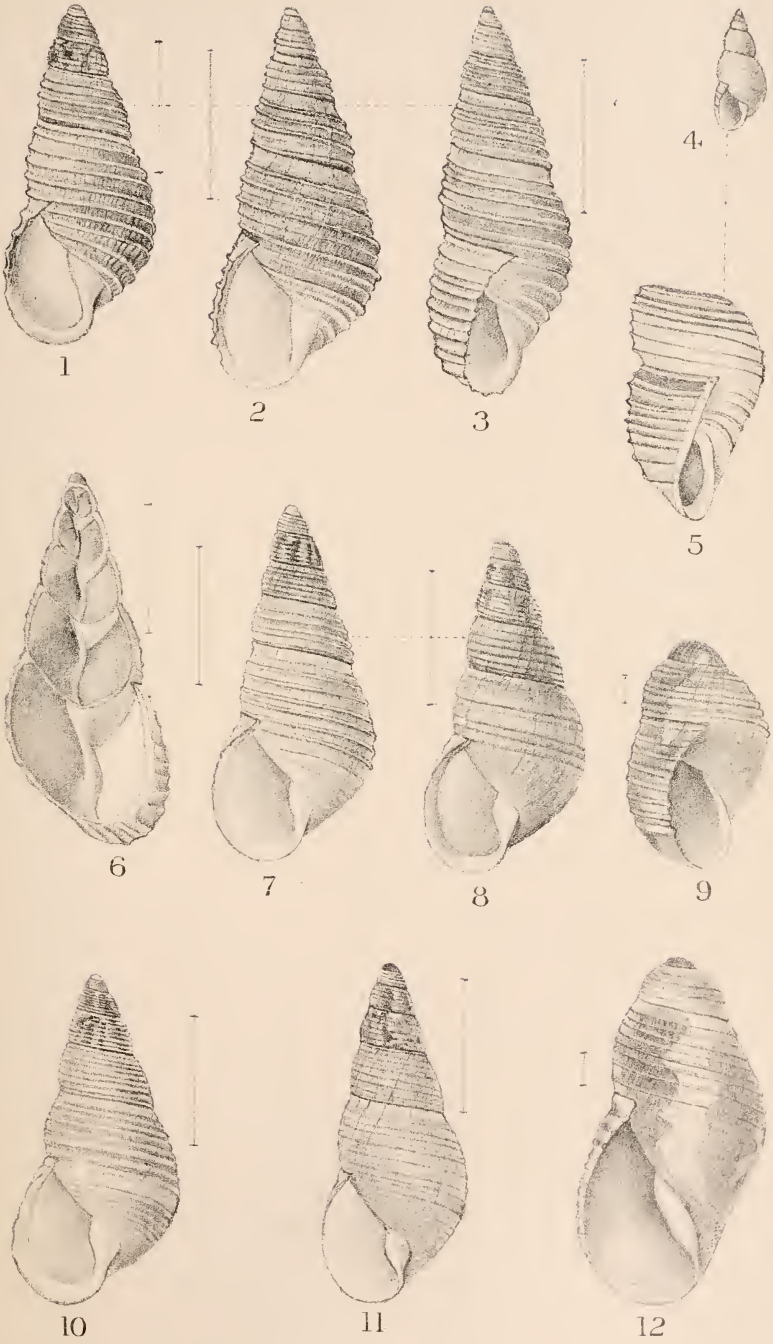
"Var. *g*. Pale yellowish brown. Passes into *A. crocea* Nob." (*Gulick*).

Specimens of Gulick's series (no. 92717 A. N. S. P.) are figured. The undescribed *A. perforata* Gulick, according to specimens (no. 57783 A. N. S. P.) is identical with *lignaria*.

34. P. FUSOIDEA (Newcomb). Pl. 15, figs. 10, 11.

"Shell sinistral, rather solid, elongately produced; whorls 6 to 7, scarcely rounded (excepting the last), margined above; suture well impressed. Aperture roundly ovate, small; columella very short, robust and twisted; lip simple above, slightly expanded below. Color straw yellow. Length 15, diam. $5\frac{1}{2}$ twentieths of an inch" (*Newc.*).

East Maui (Newcomb); Haleakala (Thwing).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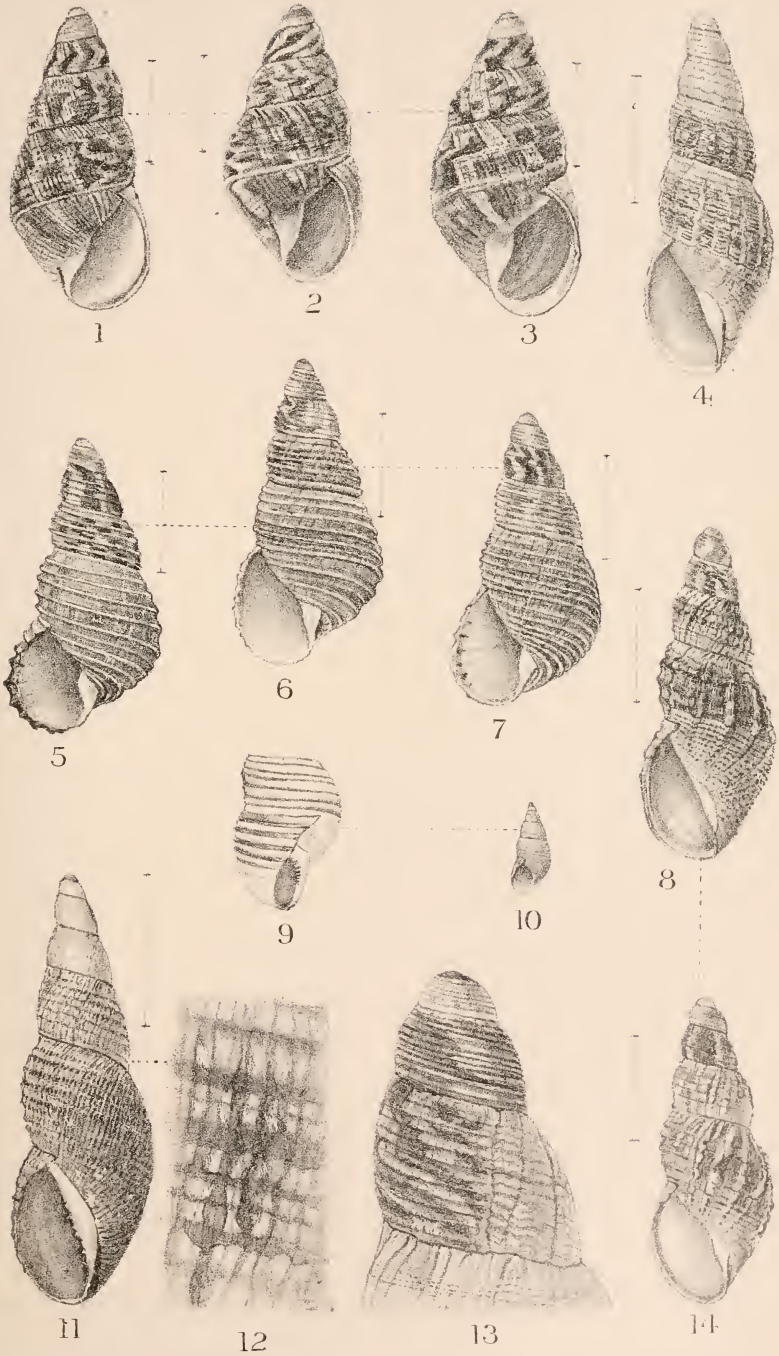
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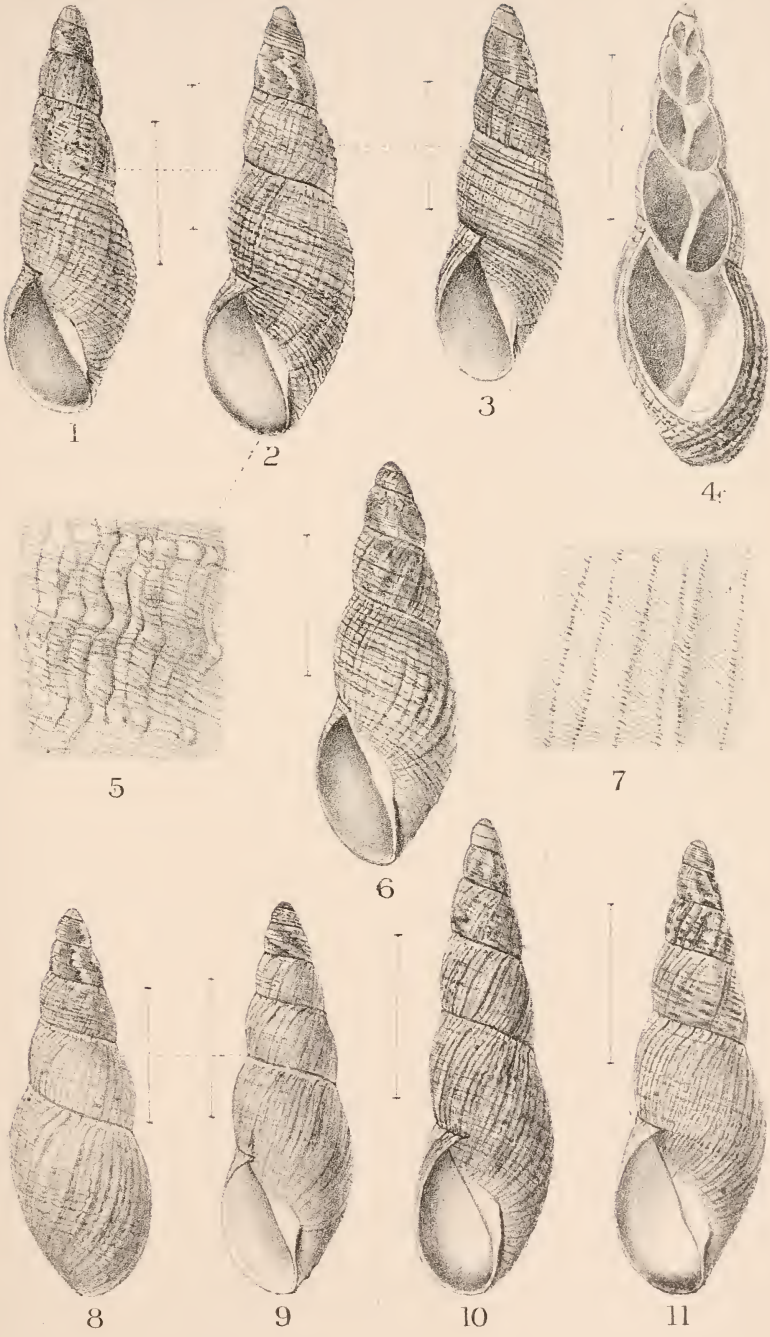
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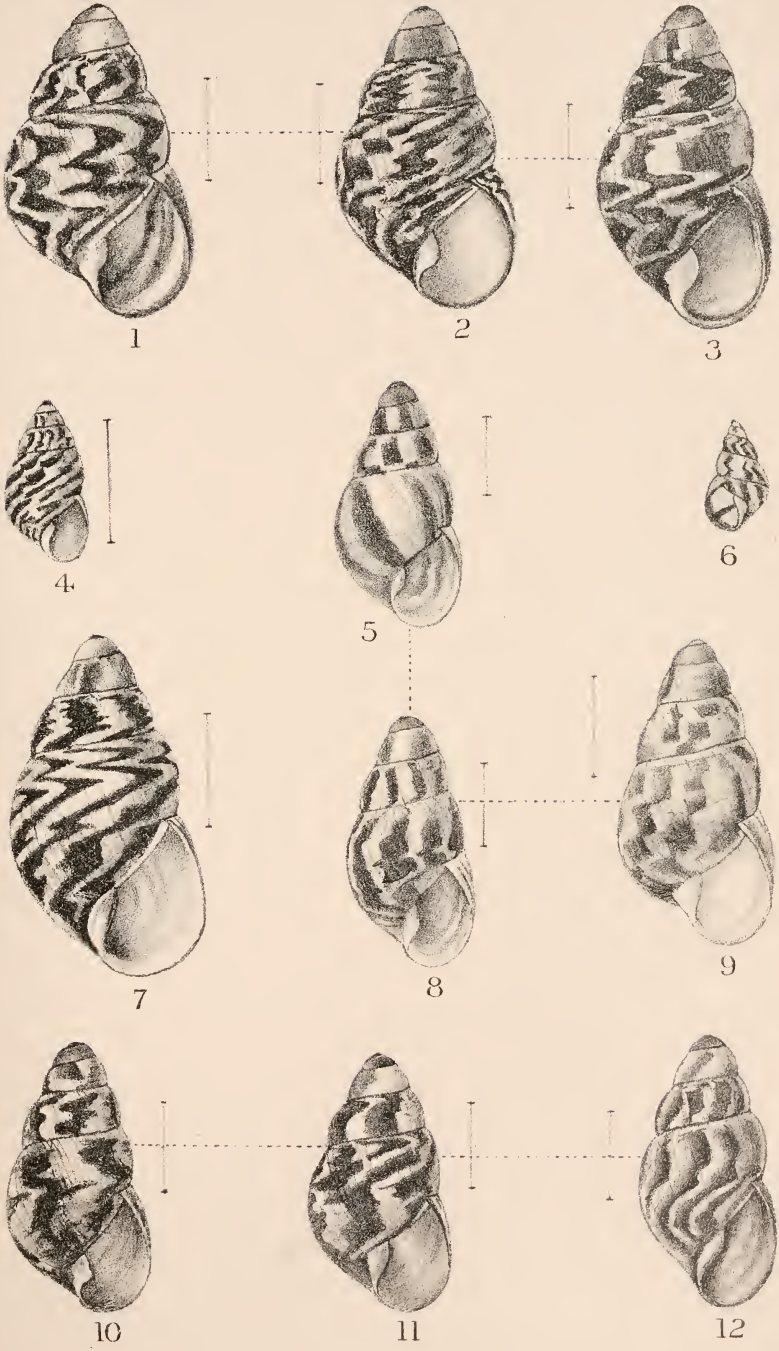
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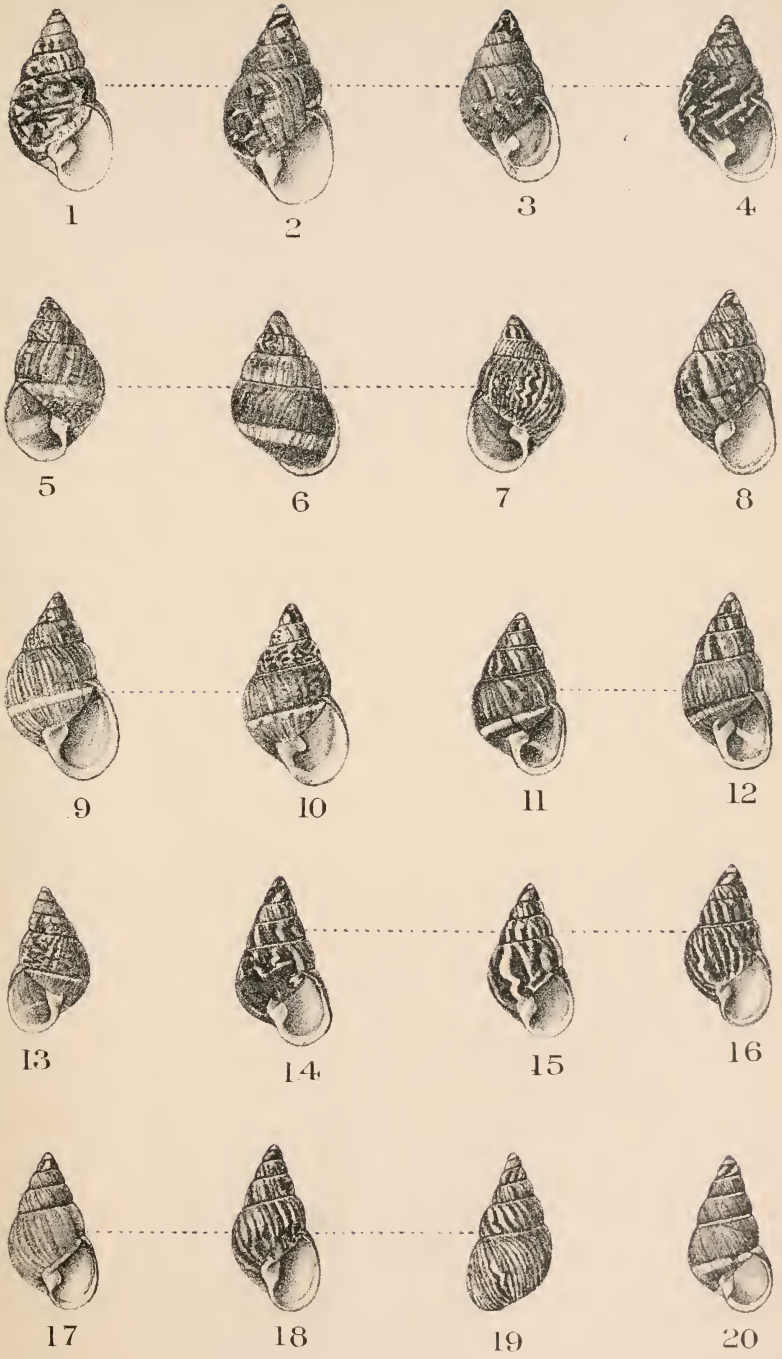
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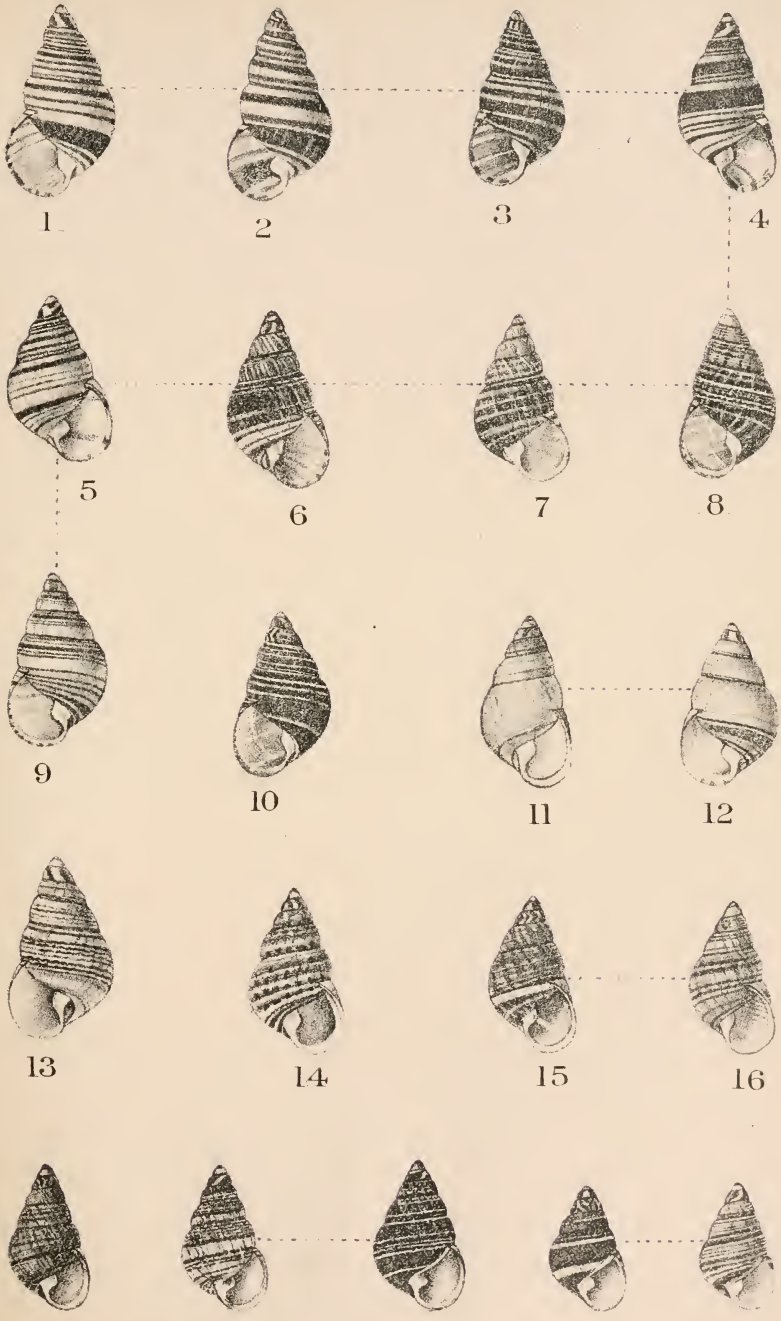
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Achatinella fusoidea Newc., Ann. Lyc. N. H. of N. Y., vi, 1856, p. 144; Amer. Journ. of Conch., ii, 1866, p. 213, pl. 13, f. 8.—Pfr., Monogr. iv, 539.—Thwing, Orig. Descript., p. 112.

"This is an exceedingly rare species, but two specimens having come under my observation, one of which serves for the illustration, the other in the cabinet of the late Hugh Cuming, in London" (*Newc.*).

This species seems close to *A. terebra* var. *longior* of West Maui, a dextral shell.

Shells from Ukumehame, West Maui (pl. 15, fig. 11), sent by Mr. D. Thaanum, agree well with Newcomb's figure of the type of *fusoidea*. They are buff with faintly darker streaks, having wide light-brown stripes on the last embryonic whorl. Under the lens the surface is weakly plicate, as in *P. terebra longior*. Length 17, diam. 8 mm.

35. P. crocea (Gulick). Pl. 13, figs. 14, 15.

"Shell dextral, perforate, conic-ovate, solid, scarcely shining, lightly striate and microscopically distinctly decussated with crowded undulating spiral lines; orange yellow; apex subacute, obliquely marked with white and yellow; spire conical; suture simple, slightly impressed; whorls 6, somewhat convex, the last slightly flattened in the middle, equal to 71 hundredths of the length; columellar fold moderately developed, white; aperture slightly oblique, sinuously oval, snowy white within; peristome not expanded, moderately thickened within; with columellar margin dilated, white, unattached; parietal margin wanting. Length 18; breadth 10; length of aperture 9⅔ mm. Weight 4 grains." (*Gulick.*)

Maui: Waihee, rare. E. Bailey, Jr. Honokowai (D. Thaanum).

Achatinella crocea Gul., Ann. Lyc. N. H. of N. Y., p. 210, pl. 7, f. 36, 1856.

The sculpture of impressed spirals and dense, fine, protractive wrinkles or ripples is very clearly developed. The color is yellowish-green (tawny-olive of Ridgway's Nomenclature of Colors), but in the young there is often more of a

gamboge tint. There is often a pale line on the periphery. Embryo pale brown, the last half whorl striped with brown. The lip is thickened within, white or flesh-tinted. Columellar fold often very strong and more or less tinted with brown, but white at the end. Figured from cotypes. Probably a variety of *A. terebra lignaria,* yet I have seen no actually intergrading specimens. It seems well characterized by the color and short contour.

In a series from Honokowai, West Maui, sent by Mr. Thaanum, the color of the last whorl varies from pale buff to dull gamboge, being darkest on the base. The spire is generally more drawn out than in the figures on plate 13, and is a little attenuated, its outlines distinctly concave or sometimes almost straight. The flames on the last embryonic whorl are occasionally lost by wear.

Species of Oahu.

36. P. MONTAGUI Pilsbry. Pl. 24, figs. 7, 8.

The shell is sinistral, perforate, thick and solid, ovate-conic, the spire acuminate, its outlines straight or somewhat concave above. Embryonic whorls distinctly striate spirally; last three whorls rudely sculptured with close, irregular wrinkles, and on the last whorl there are spirally and obliquely descending ridges producing flattened facets (as in many large Lymnæas). The minute spirals disappear on the later whorls. The upper whorls are nearly flat, the last three slightly convex, last whorl more convex, the base rather rotund. Suture superficial, sometimes having a margin defined by an impressed line on the last whorl, but in other examples this is wanting. Aperture slightly oblique. Outer and basal margins of the peristome are expanded, thick, and have a heavy callous thickening within; columellar margin raised, thick; columellar fold thick and moderately projecting.

(*a*) Length 25, diam. 14, length aperture 12 mm.; 7⅓ whorls.

(*b*) Length 24.7, diam. 12.5, length aperture 11 mm.; 7⅓ whorls.

(*c*) Length 26.9, diam. 13.1, length aperture 12.1 mm.

Oahu: Manoa road at its junction with the upper road, back of Rocky Hill, cotypes (*a*) no. 108181 A. N. S. P.; (*b*) no. 111 coll. Irwin Spalding; and (*c*) no. 33581 B. P. Bishop Mus. Also found on Rocky Hill about ¾ mile from the type locality.

Partulina montagui Pilsbry, Nautilus, xxvii, p. 40, August 1st, 1913.

This species differs strikingly from all others by its sculpture and small apical whorls. It seems to be nearest to *P. dwightii* of Molokai. No specimens yet found show any trace of color. The periphery is angular in the young, the angle persisting as far as the last whorl in some individuals.

It was first found by Dr. C. Montague Cooke. The shells occur in the humus near the surface, along the roadside, and are very rare, apparently lying in "pockets" which have been filled and covered by the wash down the slope. Probably the forest disappeared from where the shells are found not much more than a hundred years ago.

Section *Eburnella* Pease.

Eburnella Pease, P. Z. S., 1869, p. 647.—Gulick, P. Z. S., 1873, p. 91, as section of *Partulina*; *A. variabilis* selected as an example.

Very smooth, glossy shells, uniform white, yellow or brown, or variously banded, not striped longitudinally; outer lip simple or scarcely expanded; columellar fold strong. Type *P. variabilis* (Newc.).

The typical group consists of Lanaian species in which the peripheral keel persists throughout the young stages, and often upon the first half of the last whorl. In the allied groups of Molokai and Maui the keel is lost much earlier; the later stages of youth and the mature stage being round at the periphery. The group is not strongly individualized, some species, as *P. mutabilis,* showing transition to the pattern of *Perdicella,* others approaching Partulinæ of the striped group of Maui.

Eburnella was originally a heterogeneous group comprising

the following species: *A. casta* Nc., *curta* Nc., *livida* Sw., *porcellana* Nc., *recta* Nc., *saccata* Pfr., *undulata* Nc., *semicarinata* Nc., and *variabilis* Nc. Gulick, in his classification of 1873 restricted it to Lanaian species, giving *Partulina variabilis* Newc. as an example. I think it may with advantage be enlarged to include species of Molokai and Maui which seem related.

Series of P. porcellana. MAUI.

Glossy shells with weak spiral striation; uniform or with color in bands, usually few in number and well contrasted; the embryonic shell is banded above or below the suture or is plain, and has *no longitudinal or oblique markings* (except in *P. mutabilis*).

These medium-sized or small shells have much the appearance of *Achatinellastrum*, but various indications—the characteristic decurrent sculpture more or less visible on all the forms, and the vanishing zebrine stage in *P. mutabilis*—lead me to consider them modified Partulinæ. This is also the view taken by Mr. Baldwin, and suggested in Hyatt's Ms. Other authors have grouped part of them in the Oahuan section *Achatinellastrum*.

37. P. MUTABILIS Baldwin. Pl. 20, figs. 1 to 7.

Shell dextral or sinistral, minutely perforate, narrowly conical, the sides slightly concave, apex rather obtuse; solid, rather glossy, striatulate and under the lens showing weak, rippled spiral striation. "Color varying from pure white to dark fulvous, often variously striped with brown lines and bands"; usually pale buff-yellow or whitish with numerous chestnut spiral lines and bands, or snow-white throughout; the last embryonic whorl frequently striped longitudinally. Suture generally margined below. The aperture is small, white, lip very narrowly thickened within; columellar lamella white, rather strong, thick and oblique.

Length 17, diam. 8.8, aperture 7.5 mm.; 6¼ whorls.

Length 16.3, diam. 9.3, aperture 7.8 mm.; 6 whorls.

West Maui: Waiehu valley.

Partulina mutabilis BALDWIN, Nautilus, xxii, p. 68, November, 1908.

Distinct by its narrow contour, color in bands when present, and the frequent presence of a brief zebra-striped stage on the last embryonic whorl. It has a superficial resemblance to the Lanaian *A. variabilis,* which belongs however to a somewhat different series. Figured from specimens of the type lot received from Mr. Baldwin.

P. mutabilis is an important species in that it forms a connection between the Partulinæ having zebra striping and those having spiral bands only. The embryonic whorls are flattened, the first flesh-tinted. In most banded individuals some indistinct protractive brown streaks appear near the end of the second whorl, becoming stronger and angularly bent on the next fourth to half whorl, gradually giving place to spiral bands which arise about the middle of the third whorl (pl. 20, figs. 6, 7). This pattern is not essentially unlike that of *Partulina splendida.* In some individuals, however, the longitudinally striped stage is omitted, and the spiral bands appear (at first very faintly) on the latter part of the second whorl, arising from the uniform fleshy tint of the preceding part of the embryonic shell (pl. 20, fig. 5). Such shells are comparable to *P. porcellana* and its allies, and may be regarded as more accelerated than those having an obliquely striped stage.

In a series of 18 sent by Mr. Baldwin, 10 are dextral. The same color patterns are found in dextral and sinistral individuals. The variations are as follows:

(1) Pure white throughout.

(2) Pale buff, last embryonic whorl faintly striped longitudinally.

(3) White to buff-yellow with chestnut bands and lines.

38. P. PORCELLANA (Newcomb). Pl. 19, figs. 1 to 4.

"Shell rather solid, conical, polished, shining. Whorls 5, rounded, margined above. Aperture ovate; lip expanded, thin at the margin, thickened within. Columella short, tubercular. Color of a porcelain whiteness with a light fawn-

colored band encircling each whorl, the last whorl having two. Length 12, diam. six-twentieths of an inch" (*Newc.*).

East Maui (*Newcomb*): Huelo, Makawao to Nahiku (*Thwing*); Nahiku (*Baldwin*).

Achatinella porcellana Newc., P. Z. S., 1853, p. 146, pl. 23, f. 47.—Pfr., Monogr. iv, 525.—Thwing, Orig. Descriptions, p. 105, pl. 2, f. 12.

In a specimen from Newcomb the first whorl is white, a yellow band beginning on the second below the suture; but in others seen the apex is brown or blackish, a band of the same color 1½ whorls long running from it above the suture, fading into white at its upper edge, the first 1½ whorls being therefore bicolored. Then a yellow band appears faintly below the middle of the whorl, finally becoming the supraperipheral band on the last whorl. In some specimens a band bordering the suture below also is found. The last whorl has two to four bands: (1) the subsutural, often wanting; (2) one above the periphery; (3) one below it, entering the aperture at its upper angle, and sometimes there is (4) a narrow crescent around the columella. Occasionally a few spiral lines are developd in addition to these bands. These bands and lines vary from ochraceous to dark brown (mummy brown of Ridgway). The ground color is white, with a yellow tint around the columella or over the whole base. Surface glossy, with only very weak spiral striation. The lip is narrowly thickened within in adult shells, its face tinted or spotted at the bands. Columella white or brown. Specimens from Nahiku (pl. 19, figs. 1-3) measure:

Length 18, diam. 10 mm.; 6 whorls.

Length 18, diam. 10.5 mm.; 5½ whorls.

Length 15.5, diam. 9 mm.

All the shells I have seen are dextral. *A. flemingi* and *wailuaensis* are apparently varieties of *porcellana*, as Mr. Thwing has intimated. Very likely *A. fulvicans*, possibly *A. nattii* also, will eventually be included in *porcellana*.

Fig. 4 is a copy of Newcomb's figure of *porcellana*.

38*a*. *P. porcellana flemingi* Baldwin. Pl. 19, figs. 5 to 11.

Shell dextral, minutely perforate, rather solid, high-conic, glossy, with very weak traces of spiral striation or almost none; variously colored; white, bandless or with one to four dark brown bands, or light fleshy-brown with bands. Lip a little thickened within; columellar fold moderately strong.

Length 20, diam. 10 mm.; 6½ whorls.

Length 18, diam. 9.2 mm.

Length 18.2, diam. 9 mm.

Length 18.3, diam. 10 mm.

Length 17.2, diam. 9.5 mm.

"Animal when extended in motion as long as the shell. Mantle intense black with a narrow white band encircling the outer edge. Foot above and below very light-brown, granulated above. Tentacles long and slender, slate color." (*Baldwin.*)

East Maui: Nahiku (D. T. Fleming).

Partulina flemingi Baldwin, Nautilus, xix, p. 111, February, 1906.

A large set from the type lot shows great variation in coloration.

(1) White, uniform (fig. 8), or yellow tinted at base and above the suture of the embryo.

(2) White with four dark brown bands, situated below the suture, above and below the periphery and around the columella. Embryonic shell white with a yellow band below the suture or a dark band above the suture, fading upwards; columella and lip more or less purplish brown. This is the most abundant color pattern.

(3) White, with bands above and below periphery, apex lip and columella white.

(4) White, with narrow dark bands at the periphery, in the middle of the base, and a distance below the suture (fig. 5); or having a wide band above the narrow basal band (fig. 11).

(5) Ground color brownish, bands as in no. 3 (fig. 9).

This subspecies differs from *porcellana* chiefly by its nar-

rower contour. The system of banding (i. e., positions of the bands) is the same as in *porcellana.*

38*b*. *P. porcellana wailuaensis* (Sykes). Pl. 19, figs. 12, 13, 14.

Shell dextral, subperforate, glossy-turrited, rather solid, very lightly striate, white painted with chestnut lines, marked at the periphery with a white zone and in the suture a blackish-chestnut line. Whorls 5 to 5½, regularly increasing, convex. Aperture auriform; columellar margin having a moderate brown fold, the right margin acute, parietal callus very thin. Length 15.5, diam. 8.4 mm. (*Sykes*).

East Maui: Wailua (Perkins). Hana (Cooper).

Achatinella (*Achatinellastrum*) *wailuaensis* Sykes, Fauna Hawaiiensis, ii, Mollusca, p. 328, pl. 11, f. 19 (and var., f. 20), 1900.—*Partulina cooperi* Baldwin, Nautilus, xix, p. 135, April, 1906.

"A very pretty little shell of the group of *A. bella* Reeve, of Molokai. A variety also occurred (pl. 19, fig. 14) in which the banding is almost obsolete save in the suture of the earliest whorls and in one strong dark band below the periphery" (*Sykes*). Fig. 13 is copied from Mr. Sykes's type figure.

The arrangement of bands is essentially the same as in *porcellana,* but the shell is somewhat wider in contour, and the bands are typically paler and more diffuse. I have not seen specimens from Wailua.

Mr. Baldwin's *P. cooperi* from Hana (pl. 19, fig. 12, cotype) seems to belong to the same race. The shell is pale buff with a white peripheral belt bordered on both sides by ochraceous bands; base and upper surface have some diffuse paler ochrey lines or bands, and there is a darker line along the suture. Embryonic shell white or whitish with a purple spiral band above the suture and a yellow line below the suture. The columella and its fold are purplish-brown, and the narrow callus within the outer lip either white or purplish brown. A half-dozen specimens of the type lot, sent by Mr. Baldwin, show but slight variation.

Length 17, diam. 9.5 mm. (Baldwin).

Length 17.3, diam. 10 mm.

39. P. PORCELLANA FULVICANS Baldwin. Pl. 19, figs. 15, 16.

"Shell dextral or sinistral, very minutely perforated, rather thin, acuminately ovate conic, apex subacute; surface shining, marked with delicate incremental striæ, under a lens exhibiting extremely close, minute decussating spiral striæ; nuclear whorls faintly cross-lined. Color very light yellow, or sometimes white with one or two light yellowish transverse lines; a conspicuous dark band near the apex. Whorls 6, somewhat convex, narrowly margined above; suture well impressed. Aperture oblique, oval, white within. Peristome acute, slightly thickened within, columellar margin narrowly reflexed. Columella terminating in a strong white flexuous fold. Length 18½, diam. 10½ mm." (*Baldwin*).

East Maui: Kipahula Valley, Hana (G. O. Cooper; D. Thaanum).

Partulina fulvicans BALDWIN, Nautilus, xix, p. 135, April, 1906.

Topotypes from Mr. Baldwin are figured. Fig. 16 is greenish-yellow with the embryo nearly white, without a dark band. Fig. 15 is white above the periphery, light olive below, the embryo bicolored, being white, broadly banded with flesh color above the suture, the band extending to the apex. Other shells are greenish-yellow, fading upwards to white at the suture and with a faint light peripheral band, the embryo having a rather dark olive or brown band. The shell is glossy, with the *Partulina* spiral sculpture but faintly developed. It differs from *Partulina crocea* by the gloss, faint sculpture, and differently colored embryonic shell. It is very closely related to *A. porcellana* and *wailuaensis* from which it differs only in coloration, the dark bands being absent, and the aperture white throughout. I do not know whether it occurs in a pure colony, but presume this is the case. Mr. Baldwin remarks: "The sinistral variety may prove to be a distinct species. The molluscan life of this rather secluded valley has only recently been explored."

40. P. NATTII (Baldwin et Hartman). Pl. 20, figs. 8, 9, 10, 11.

"Shell dextral, turbinate, spire half the length; whorls 5,

polished, the two last rapidly enlarged and inflated. Suture impressed, columella yellow, stout and twisted. Color bright gamboge yellow, with one white and three wide chestnut bands beneath the suture, the latter visible from within the aperture; aperture round ovate, white, labium white, slightly thickened within. Length 16, diam. 10, length aperture 8, width 5 mm." (*Hartm.*)

East Maui: Makawao (Baldwin); Makawao to Honomanu (Baldwin).

A.[*chatinella*] *nattii* Baldw. Nobis (*Achatinellastrum*), HARTMAN, Proc. A. N. S. Phila., 1888, p. 34, pl. 1, f. 3 (*Achatinellastrum nealii* in explanation of plate, p. 56).—THWING, Orig. Descriptions, p. 106.

"This with the preceding, *A. porcellana* Newc., and *A. flemingi* Bald. MS., and also *A. wailuaensis* Sykes, form a group very similar in appearance and which run together" (*Thwing*).

P. nattii, of which we figure specimens from Baldwin, differs from *porcellana* by its stouter contour and *the positions of the bands,* which are quite definitely located in 27 specimens examined. There is one brown band a short distance below the suture, another at the periphery, and a third about midway between periphery and columella, this one usually being the widest. The peripheral band shows above the suture on the spire, but there is no dark band or margin along the suture. The bands vary in color from chestnut to ochraceous. The ground may be white throughout, but it is usually snow-white between the suture and upper band, and elsewhere gamboge yellow. The embryonic shell is rarely white, usually some shade of brownish-yellow with a white line or band below the suture. About the end of the second whorl this solid color splits into two bands which become the upper and peripheral.

The embryo and early whorls are quite distinctly engraved spirally, but on the last whorl this sculpture is very weak. The surface is glossy. The lip is white except where colored by the bands, and the strong, oblique columellar fold is invariably white. Sutural margin usually set off by an impressed line.

Length 16.8, diam. 11, aperture 9 mm.; 5⅓ whorls.

Length 18, diam. 11, aperture 9 mm.; 5½ whorls.

While *nattii* is very closely related to *porcellana,* I have seen no intergrading specimens and therefore allow it to stand as a species.

A variety in the C. M. Cooke collection from Honomanu (Baldwin) has light ochraceous bands on a gamboge ground and no snowy sutural band.

41. P. ANCEYANA (Baldwin). Pl. 20, figs. 12, 13, 14.

Shell dextral, imperforate, rather thin, oblong-conic, the summit obtuse. Embryonic shell chestnut, fading to, or banded with white above; following whorls chestnut with a white line revolving a short distance below the suture, and on the penult. whorl another above the suture; last whorl rich yellowish-chestnut with a white line near the suture, another at the periphery, the latter bordered below with a yellow band. Another yellow band, usually wider, occupies the base, leaving a small dark patch around the axis. The surface is glossy, with sculpture of fine crenulated spirals throughout. Aperture slightly oblique, brown-banded within; lip not expanded, narrowly thickened within. Columellar fold brown or brown and white.

Length 14.5, diam. 8.5 mm.; 5 whorls.

Length 14, diam. 9 mm.

Length 15.5, diam. 8.3 mm.

" Animal when extended in motion longer than the shell. Mantle light-brown mottled with black, outer edge encircled with an interrupted orange band. Foot above and below a very light brown, superior portion with a slate tinge, posterior portion tapering and sometimes with a yellowish tinge. Tentacles long, light-slate. Head above minutely granulated " (*Baldwin*).

East Maui: Makawao, in forests of the exterior slope of the extinct Haleakala crater at an altitude of 4,000 ft., living on foliage near the tops of the trees (*Baldwin*). Type no. 65707 A. N. S. P.

Achatinella anceyana Baldwin, Proc. A. N. S. Phila., 1895,

p. 223, pl. 10, f. 16.—Thwing, Reprint Orig. Descript. Achat., pl. 2, f. 15.

This species is related to *P. porcellana wailuaensis* and perhaps to *A. germana,* of which it is thought by Dr. Cooke to be a small race. " It is remarkable for the constancy of its delicate color lines; over 200 examples before me show only trifling divergence in this respect " (*Baldw.*). In one specimen of the lot sent by Mr. Baldwin, the lower yellow band is reduced to a line. In some others the ground-color is pale fleshy-brown above the periphery. There is some variation in shape, as shown in the figures. It was named for the late C. F. Ancey. Lives on bark of the guava.

42. P. GERMANA (Newcomb). Pl. 20, fig. 15.

" Shell dextral, ovately conical; whorls 6, flatly convex. Aperture ovate; lip acute, thickened within. Columella brown, short and tubercular. Color chestnut, with fine, obsolete, darker, transverse lines; a white band traverses the last sutural whorl and cuts the body-whorl centrally; around the columella is a broad white band, losing itself in the aperture. Length sixteen, diam. eight-twentieths inch " (*Newc.*).

East Maui: Makawao (Newc.).

Achatinella germana Newc., P. Z. S., 1853, p. 151, pl. 24, f. 61, 1854.—Pfr., Monogr., iv, 533.—Thwing, Orig. Descript. p. 109.—*A.* (*Achatinellastrum*) *germana* Nc., Sykes, Fauna Hawaiiensis, p. 324.

" Closely resembles the *A. solitaria,* and but for the widely-distant localities might be taken for varieties of the same species. The markings and columellæ are however quite distinct " (*Newc.*).

Known to us by the original account only. I can only suggest its probable relationship to *P. anceyana* and *P. wailuaensis,* both of which differ in being of a more oblong shape and smaller size, *P. germana* measuring length 20, diam. 10 mm. according to Newcomb.

Series of P. mighelsiana. MOLOKAI.

Rather small shells with a high polish, weak or almost wanting spiral striation, and bright coloring—yellow often with white or chestnut bands, or white or chestnut throughout; never striped longitudinally; lip unexpanded. Embryo spirally banded or plain.

These shells are related to the *variabilis* group of Lanai and the *porcellana* group of Maui. Whether they belong to the Oahuan group *Achatinellastrum,* or represent a branch of *Partulina* convergent towards that Oahuan group, remains uncertain. In Hyatt's earlier writings he placed part of these species in *Achatinellastrum,* but later he doubted this grouping, and was disposed to view them as modified Partulinæ. As there are Maui-Molokai types in Oahu, such as *Laminella* and *Partulina dubia,* there seems no good reason why some Achatinellas of Oahuan type should not occur in the more eastern islands.

For the present I leave the *mighelsiana* group in *Partulina* for the reason that among the related Mauian species it would be very difficult to draw the line between *Partulina* and *Achatinellastrum.* The coloration of the embryonic shell is more like that of *P. virgulata* than like the ordinary Partulinas. Dr. Cooke suggested that in view of the numerous forms of intermediate character between the three conventional species of the *mighelsiana* group, it would be more logical to rank *bella* and *polita* as subspecies of *mighelsiana.*

43. P. MIGHELSIANA (Pfeiffer). Pl. 18, figs. 10 to 17.

" Shell ovate-coniform, smooth, opaque, glossy; snow-white variegated with ashy streaks. Spire conic, the apex rather acute, suture somewhat margined. Whorls 5½, convex, the last encircled with a blackish line (sometimes doubled) below the middle. Columellar fold strong, tooth-like, chestnut colored at the base. Aperture semi-oval, brown-margined; peristome simple, acute. Length 17, diam. 8 mm., aperture 8½ mm. long, 4 wide (*Pfr.*).

Molokai (Cuming coll.): Kalae (Baldwin, Thaanum); Kilo-

hana (Cooke and Pilsbry); Kalae, Puunea, Iloli, Waileia, Maunahui and Kaamola (Borcherding, coll. Meyer).

Achatinella mighelsiana Pfr., P. Z. S., 1847, p. 231; Monogr. ii, 238, 1848.—Reeve, Conch. Icon., vi, pl. 5, f. 40, April, 1850.—Newcomb, Ann. Lyc. N. H., vi, 319 (animal).—Sykes, Fauna Hawaiiensis, p. 314.—Baldwin, Catalogue, p. 6.—Gwatkin, Proc. A. N. S. Phila., 1895, p. 238 (radula).—Thwing, Orig. Descript., p. 97.—*Achatinellastrum mighelsiana* Pfr., Borcherding, Zoologica, xix, p. 79, pl. 7, f. 1-13, 15, 17, 19; with var. *martensi*, p. 80, pl. 7, f. 14, 16, 18, 20.

The shell is dextral, perforate, very smooth and glossy, porcelain-like, showing weak spiral striæ under a lens. The typical form is white with narrow gray streaks and a black-brown belt just below the periphery, and a narrow blackish submargin in the lip. The embryonic whorls are white (fig. 13). This pattern varies to forms having the ground white without streaks, or buff, with or without yellow streaks. The subperipheral belt may be split, or rarely another band defines an umbilical area. Probably Kalae is the type locality.

(*b*) White, without bands or streaks (fig. 15) Kalae.

(*c*) White, with or without gray streaks, and variously banded and lineate (figs. 10-12). This is var. *martensi* of Borcherding.

(*d*) Pale yellow, with several bands, embryonic shell brown with a white band above.

(*e*) White, with yellowish-brown streaks interrupted by spiral white bands (fig. 16).

(*f*) Similar to the type, but the base is yellow (fig. 17) Kalae.

Well-grown specimens measure length 19, diam. 10 mm.

Borcherding describes a var. *martensi* as differing from the type by: white color, well-impressed suture, the whorls more convex, encircled by lines either wide or narrow, the last whorl having the typical broad brown peripheral band, columella light reddish, the lip never bordered within with brown, interior fleshy-white. Pl. 18, figs. 10-12 represent this color-form. It is from Kawela. The rounded whorls and deep suture are equally well marked in some specimens of other

color-patterns. The same color-pattern occurs in Kilohana. There is a similarly marked form of *polita*.

43*a*. P. MIGHELSIANA BELLA (Reeve). Pl. 23, figs. 2 to 12; pl. 26, f. 13 to 15*e*.

" Shell conical, dextral, whorls rather ventricose, columella with a twisted plait. Olive-yellow, sutures black-brown, then white-banded, last whorl brown and white banded. The dark sutural band is sometimes absent in the last whorl, but the white band appears constant " (*Reeve*).

" Animal of a uniform yellowish-white, with slate colored tentacles " (*Newcomb*).

Molokai (Cuming coll.), Puunea, on leaves of small trees (Cooke and Pilsbry), Kalae, Kealia, Kaupelua, Waileia, Kaunakakai, Maunahui, Hanakalilolilo, Kawela, Ualapue and Kaluaaha (Borcherding, Meyer coll.).

Achatinella bella REEVE, Conch. Icon., vi, pl. 3, f. 17, April, 1850.—PFEIFER, Monogr. iii, 461.—SYKES, Fauna Hawaiiensis, p. 321.—NEWCOMB, Ann. Lyc. N. H., vi, p. 316 (animal).—BALDWIN, Catalogue, p. 6.—THWING, Reprint Orig. Descript. Achat., pl. 2, f. 5.—*Achatinellastrum bella* Rve., BORCHERDING, Zoologica, xix, p. 77, pl. 6, f. 11-20.

The shell is dextral in the large number seen. The early whorls are closely striate spirally, but the last whorl has only faint traces of spirals on the glossy surface. Columellar fold very strong. Axis imperforate. The spire is shorter and stouter than in *mighelsiana*, but it must be admitted that some forms, such as color-var. *e*, approach that species. *P. polita* differs chiefly by its bulging last whorl, narrower spire and diverse coloration—wanting white bands.

In my opinion, supported by Dr. Cooke, the forms figured for *polita* by Borcherding, on his plate 8, figures 1 to 7, pertain to *bella*.

The color-forms are as follows: (*a*) Typical form; embryonic whorls white or black-tipped; last whorl yellow with a chestnut band bordering the suture followed by a white band, another just below the periphery with a white band above it; columella fleshy-brown, the tooth and aperture

fleshy-pink. Length 16, diam. 9 to 10 mm. See pl. 23, fig. 12 (copy from Reeve). Embryos of this form show very pale wax-yellow bands proceeding from a yellow apex, which apparently fade out in the adult stage. Waikolo and Puunea specimens correspond exactly with Reeve's figure. The original locality was probably Kalae, or perhaps Puunea, within easy walking distance from Kalae. A series collected by Cooke and Pilsbry in Puunea is figured, pl. 26, figs. 13 to 13*c*. A little further north, between Puunea and Kilohana, there are transition forms to *mighelsiana,* pl. 26, fig. 14, both color and shape being intermediate in various examples. This place is not far from the northern cliff.

(*b*) Similar to the above, but lacking the peripheral chestnut band. Occurs with the typical pattern.

(*c*) Both sutural and peripheral bands wanting. Columella and aperture white or pink.

(*d*) Variously banded with chestnut, the bands often occupying most of the surface. Kalae (Meyer).

(*e*) White, variously banded with chestnut or with a sutural line only, or no bands whatever, the umbilical region alone yellow tinted, or sometimes also white.

(*f*) Bicolored, white above, greenish-yellow or olive below the periphery. Aperture and columella white or pink. May be a derivative of forms *g* or *c*.

(*g*) Same as *f*, but having a dark sutural line, sometimes a subperipheral line also, and occasionally an olive line in the middle of the upper surface. Fig. 9. This form is evidently a derivative of the typical *bella* pattern.

Whether the more eastern of Borcherding's localities really have *bella* forms I do not know, but the typical *bella* country is in the region southward of the Leper Settlement peninsula. A series from Ualapue, collected by Mr. Thaanum (pl. 26, figs. 15 to 15*e*) seems to carry *bella* into the *polita* area. I do not know the locality of pl. 23, figs. 2-8, collected by Mr. Meyer.

43*b*. P. MIGHELSIANA POLITA (Newcomb). Pl. 24, figs. 1 to 6.

Shell dextral, conic-ovate, polished, light-yellow, a portion

of the upper whorls marked with umber, suture with a broad black band, and a narrow line of the same color continued around the body-whorl. Whorls 5, convex; suture well defined, margined. Aperture oblong-ovate, dark purple; columella with a large tubercle tipped with purple; lip simple. Length .55, breadth .45 inch (*Newc.*).

Animal of a uniform yellowish-white, including tentacles; tentacular sheath slightly tinged with brown; mantle black (*Newcomb*).

Molokai (Newcomb), Kaluaaha to Halawa (Baldwin; Bishop Museum), Kawela, Kaamola and Ualapue (Borcherding).

Achatinella polita Newc., Annals of the Lyceum of Nat. Hist. of N. Y., vi, p. 24, May, 1853; t. c. p. 328 (description of animal); P. Z. S., 1853, p. 142, pl. 23, f. 37.—Pfr., Monogr., iv, 536.—Baldwin, Catalogue, p. 81.—Thwing, Reprints Orig. Descript. Achat., pl. 2, f. 9.—*Achatinellastrum polita* Nc., Borcherding, Zoologica, xix, p. 81, pl. 8, f. 8, 9.

The typical *polita* has the upper 3 whorls bicolored, dark yellow, chestnut or olive with a white band below the suture; following whorls paler, Naples yellow to wax yellow or olive ocher, with a chocolate band below the suture. This is the form figured by Newcomb as typical. One of his specimens is drawn in pl. 24, fig. 2. In his description he mentions a line of the same color (black) upon the body-whorl. Figs. 3, 4 represent specimens from Newcomb so marked. The aperture is purplish within, varying in shade. Length 13.7, diam. 9 mm., 5½ whorls, to length 15, diam. 9.2 mm.

Newcomb's type locality was doubtless Kaluaaha or the adjoining valley east, Mapulehu, where specimens exactly like the types are found. It is likely that Newcomb stayed with Mr. Hitchcock, a missionary who lived at Kaluaaha, and had a place at Kalae. Mapulehu shells are further illustrated in pl. 24, figs. 5, 6, collected by Mr. Thaanum.

Another form is larger, up to length 18, diam. 10 mm., with the embryonic 3 whorls white with a minute dusky tip, following whorls yellow (often paler on the last whorl), suture edged below with a dark line or none. The aperture is of a purplish tint, darker or dark-streaked near the lip.

P. polita differs from *P. bella* by its bulging last whorl, which gives the sides of the spire a concave outline. In *bella* the general outlines of the spire are straight. The color-patterns are also different. *P. polita* is never white and never has white bands on the last whorl. It is also more distinctly striated spirally, the striæ visible though often weak on the last whorl.

Color-form *latizona* Borcherding. Pl. 23, fig. 13. Shell dextral, conic-ovate, rather solid, glossy, very delicately longitudinally striate; epidermis pale-yellow, the whorls encircled in the middle with a broad chestnut-brown band; spire conic; suture margined, impressed. Whorls 5½, weakly convex, the last scarcely broader than the spire. Columella having a small, short, white tubercle. Aperture oblique, inversely auriform, pale violet; peristome simple, unexpanded, red-lipped within. Length 14, diam. 8 mm. Kaamola, Meyer (*Borcherding*).

Achatinellastrum latizona Borch., Zoologica, xix, Heft 48[1], p. 82, pl. 8, f. 10, 1906.

Doctor Cooke collected this form in Kaluaaha and Mapulehu. It is a further development of the ordinary banded *polita.*

Color-form *dixoni* Borcherding. Pl. 23, figs. 14, 15, 16.

Shell dextral, ovate-conic, rather solid, glossy, deep chestnut-brown, the upper whorls and a patch around the umbilicus yellow; very delicately striated longitudinally. Spire conic; suture margined, impressed; whorls 5½, weakly convex, the last rounded, scarcely half the total length of the shell. Columella having a small short, flesh-red or dirty-purple tooth. Aperture oblique, half-oval, gray-violet; peristome simple, unexpanded. Length 14, diam. 8 to 9 mm. Kawela and Kaamola, Meyer (*Borcherding*).

Achatinellastrum dixoni Borch., Zoologica, xix, p. 83, pl. 8, f. 11, 12, 13, 14, 1906.

" This species occurs in the above-mentioned localities in a darker and a lighter coloring. Fig. 14 comes from Kawela, has a dark columellar tooth and no yellow patch around the umbilicus. Others from Kawela and fig. 15 from Kaamola

are normally colored. Fig. 16 from Kawela shows the lighter coloration, in which there are usually two yellowish bands, one at the periphery, the other below the suture " (*Borcherding*).

Merely the culmination of the dark phase of *polita*. Similar shells have been taken by Doctor Cooke on Mapulehu ridge.

Color-form *hepatica* Borcherding. Pl. 23, figs. 17, 18.

Shell dextral, long ovate, rather strong, glossy, with longitudinal and spiral lines, visible under the lens only, very fine and not decussating. Surface yellow-greenish, liver-brown, veined with darker streaks. Spire turrited; suture distinctly margined, impressed. Whorls 5½, convex, the last a little wider than spire, rounded. Columella weakly twisted; columellar fold white. Aperture oblique, half-ovate, whitish within; peristome simple, unexpanded. Length 17, diam. 9 mm. (*Borch.*).

Molokai: Kawela (fig. 17), Waileia (fig. 18).

Achatinellastrum hepaticum Borcherding, Zoologica, xix, p. 83, pl. 8, f. 15, 16.

The largest in Dr. Cooke's collection measures length 17, diam. 11 mm. Others taken by Father Dutton are smaller. The interior is white or pale purple.

Series of P. variabilis. Lanai.

44. P. variabilis (Newcomb). Pl. 21, fig. 14; pl. 22, figs. 1 to 12.

" Shell sinistral or dextral, conically acuminate, polished, shining; whorls 6, rounded, lightly margined above. Aperture roundly ovate; columella short, armed with a strong tubercle of a roseate color; lip expanded, acute. Color of shell white, yellow, black and other shades, plain or with from one to six bands of various colors on the last whorl. Length 8, width 14-twentieths inch " (*Newc.*).

Lanai (Newcomb, Thaanum and others); Windward side, on ridges facing Maui, above Waiapaa, behind Koele, and Lanaihale (Perkins).

Achatinella veriabilis Newc., P. Z. S., 1853, p. 154, pl. 24,

f. 70 (1854); Ann. Lyc., vi, p. 333.—Pfr., Monogr., iv, 256; vi, 169.—Sykes, Fauna Hawaiiensis, p. 319.—Thwing, Reprint Orig. Descript. Achat., pl. 2, f. 11.—*Achatinella fulva* Newcomb, Pfr., P. Z. S., 1855, p. 208 (1856).—*Achatinella lactea* Gulick, Ann. Lyc. vi, p. 198, 1856.

Dr. Newcomb included several color-forms in his original description, but the dextral shell with several blackish-chestnut bands and an umbilical patch, depicted in his figure, may be taken as the typical form. It is copied in my pl. 21, fig. 14. In the lot given by him to the Academy there are two dextral and nine sinistral shells, three having a dark umbilical patch, the others white there. Fully adult shells are rather pot-bellied, the base being notably convex (especially as viewed dorsally), but in some shells with thickened lip the juvenile character of an acute peripheral angle is retained for a short distance in front of the aperture. Three of the Newcomb lot are figured, pl. 22, figs. 1, 2, 3, to show the variation of shape and pattern.

A lot of 48 shells, from Gulick, all sinistral, shows substantially the same forms and banding (pl. 22, figs. 4 to 9). The bands are either deep chocolate or ochraceous, and vary from rather wide to linear. As in the Newcomb set, some shells are quite narrow, the dimensions being about as follows:

Length 18, diam. 10 mm., average specimen.

Length 15, diam. 10 mm., rare broad form.

Length 15.3, diam. 8.5 mm., narrow form.

Four in the lot are brownish-tawny with extremely weak bands or none; the rest are banded with chocolate and with ochraceous in about equal numbers.

Another lot from "Large Valley, Lanai," Gulick, contains 11 shells all dextral, color white, with ochraceous or dark chestnut bands. A lot of 7 from Mr. D. Thaanum is also entirely dextral, beautifully polished and chocolate-banded.

Another lot of 58 shells from Mr. Thaanum is polymorphic, (*a*) Three-banded with dark chestnut or ochraceous, the umbilical region always white, sometimes with a few accessory lines, 25 specimens, all sinistral, fig. 10. (*b*) bands reduced to lines or split, the upper one often wanting, 10 specimens,

all sinistral. (*c*) White, with a faint yellow or brown stain within the lip-callus, 7 shells, one of them sinistral. Resembles *lactea* except in the paler aperture. Fig. 11. (*d*) Cream colored, darker towards the base, to ochraceous with darker streaks, bandless, the peripheral angle usually conspicuous, but wanting in 7 shells; 16 specimens, six of them sinistral, pl. 22, fig. 12. Of 4 embryos taken from a banded shell, fig. 10, three are banded as in pl. 21, fig. 16, the fourth, fig. 17, being ochraceous with a white band below the periphery, which is more distinctly carinate than in the others. Of 5 embryos from a pure white shell, fig. 11, three are distinctly ochraceous, one having a white band below the periphery; the others being white.

It appears that some colonies are exclusively sinistral, others wholly dextral, the same color-patterns running through both. Other colonies contain both sinistral and dextral forms, and a variety of color-patterns, which are unlike in the proportions of sinistral and dextral individuals. In mixed colonies, left-handed coil and banding seem to be dominant, right-handedness and plain color recessive. The diversity of young taken from one parent indicates hybridity between the color-forms, but data are wanting to show whether sinistral and dextral forms hybridize.

The three-banded type, with bands placed as in the Mauian *P. nattii,* is probably the most fundamental (or nearest to the ancestral) pattern.

A. fulva (' Newcomb ' Pfr.), pl. 22, figs. 13, 14, is not distinguishable from the tawny-ochraceous form occurring in colonies of *variabilis.* In some specimens the periphery is acute in front of the aperture, but in others more accelerated it is rounded. The original description follows: Shell subperforate, turrite-conic, solid, striatulate, and under a lens very delicately decussate, glossy, buff-tawny; spire subconcavely conic, the apex white, acute, suture thread-margined; whorls 6½, the upper flat, following ones convex, the last a little over one-third the total length, swollen below the suture, base sac-like. Aperture oblique, subtetragonal-auriform, columellar fold superior, nodiform, orange colored;

peristome unexpanded, labiate within, the right margin somewhat straightened, columellar margin dilated, vaultingly reflexed. Length 18½, diam. 9, aperture 8 x83⅔ mm. Sandwich Is. (*Pfr.*).

Dr. Newcomb and all more recent authors have agreed in considering *A. fulva* a synonym of *variabilis*. Specimens measure: Length 17 to 18, diam. 10, aperture 8.3 mm. The lip-callus is white, or brown with a white lip-edge. The widest specimens approach *semicarinata,* but none are so wide as that. It is sometimes cream-white.

Mr. Thaanum found *P. variabilis* lower, *P. semicarinata* higher on the main ridge of Lanai.

44*a*. Var. *lactea* Gulick). Pl. 22, figs. 15, 16.

" Shell sinistral, perforate, acuminately ovate, solid, shining, finely striated, and microscopically very finely decussated, color ivory white; apex acute; spire conical, with outlines slightly convex; suture marginate, slightly impressed; whorls 6½, flatly convex; columellar fold central, brown, strong; aperture oblique, sinuately oval, reddish brown within; peristome white, thickened within; with external margin arcuate, slightly reflected anteriorly; columellar margin dilated, slightly detached; parietal margin thin. Length 22, breadth 11⅖; length of body-whorl 15 mm. Weight 8 grains " (*Gulick*).

Lanai: S. T. Alexander, D. Thaanum.

The shell is rather snow-white than ivory-white, the columella brown, tip of the fold paler, lip-callus purple-brown, interior lilac. The spire is straightly conic, whorls but very slightly convex. It is minutely but constantly perforate. It is a very beautiful shell, differing from the white form occurring in some *variabilis* colonies by its darker aperture. In a series of about fifty before me, all are sinistral.

Length 18 to 19, diam. 10 mm.

Length 16.8, diam. 9 mm.

45. P. SEMICARINATA (Newcomb). Pl. 21, figs. 1 to 4, 13, 15.

" Shell dextrorsal, solid, ovately-conical, longitudinally substriated; whorls 5, flattened, marginate above the last, an-

gulated in the middle and semicarinated. Aperture ovate; columella ending in a tortuous, obtuse, dentiform plait; outer lip anteriorly produced, strongly marginate within. Color pale yellow, aperture white internally. A straw-colored, conical species, with the last whorl partially surrounded with an elevated keel '' (*Newcomb*). No dimensions given.

Lanai (Newcomb, Thaanum *et al.*) ; mountains at high elevations (Perkins) ; at the crest of the main ridge, extending a little way down (Thaanum).

Achatinella semicarinata Newc., P. Z. S., 1853, p. 156, pl. 24, f. 76, 1864.—Pfr., Monogr., iv, 532.—*Achatinella variabilis* var. *semicarinata* Sykes, Fauna Hawaiiensis, p. 320.

This species differs from *P. variabilis fulva* by its decidedly broader contour and dextral coil. The glossy surface shows only weak traces of spiral striation. The aperture, lip-rib and columella are white, or in the darkest shells, the interior is faintly pink tinted. The early whorls are the color of the shell in most specimens, but in some they show distinct dark bands. Embryo shells usually show bands, though not always so distinct as in fig. 15, an embryo from a cream-colored mother. The color of adults varies from white to tawny or light orange-rufous. The acute carina may extend half way around the last whorl, or it may not be developed at all there, ending on the penultimate whorl. Usually it extends part way across the front of the shell. The axis is perforate. In a series of 23 from Thaanum and Baldwin, all are dextral. Newcomb's type figure is copied in pl. 21, fig. 13. It represents the most strongly carinate form. The size varies.

Length 18, diam. 12 mm.

Length 17.5, diam. 11 mm.

Length 16, diam. 11 mm.

Length 15, diam. 9.5 mm.

Mr. Sykes ranked *semicarinata* as a variety of *variabilis* on account of the difficulty he experienced in endeavoring to separate it from *fulva*. '' Mr. Perkins remarks that ' the broader form with ridge more raised is from higher elevations.' It appears to be gradually replaced by the form *fulva* at lower altitudes.'' I have here retained *semicarinata* as a

species because in the large series of both species seen the intergrading specimens are comparatively very rare. Nearest to Koela the white form occurs, further along the ridge the darker forms. Either sinistral or dextral forms may predominate in different colonies. Fig. 13 is copied from Newcomb's type figure. Figs. 1-4, 15 are from specimens taken by Mr. Thaanum.

45*a*. Var. *hayseldeni* Baldwin. Pl. 21, figs. 5 to 12.

"Shell sinistral, minutely perforated, rather solid, ovately conical, apex subacute; surface shining, marked with delicate incremental striæ, and under a lens exhibiting very close, minute, decussating spiral lines; embryonic whorls faintly cross-lined. Color generally of a uniform reddish-brown; sometimes the coloring of the middle portion of the whorl shades into white on the apical whorls, and in some examples a white line revolves below the suture. Whorls 5½, slightly convex, narrowly margined above, the last carinated or angulated at the periphery, the angle becoming almost obsolete towards the aperture; suture distinctly impressed and often margined above by the continuation of the peripheral keel. Aperture oblique, subovate, white within with a pinkish tinge; peristome white, rather obtuse, thickened within, the basal and columellar margins slightly reflexed; columella terminating in a strong, flexuous, white fold. Length 17½, diam. 10 mm.

"Animal when extended in motion longer than the shell. Mantle slate color with a brown band encircling the outer edge. Foot above and below almost white with a yellowish tinge. Tentacles white tinged with slate" (*Baldwin*).

Lanai (Walter H. Hayselden); Lanaihale, near highest point of mountain (Perkins, Thaanum).

Partulina hayseldeni Baldwin, Nautilus, x, p. 31, July, 1896.—*Achatinella* (*Partulina*) *hayseldeni* Baldwin, Sykes, Fauna Hawaiiensis, p. 313, pl. 11, f. 2.

"This species is allied to *P. semicarinata* Newc., which is found in another district of the same island. The latter is a light straw-colored, more conical, and invariably dextral

shell. The animals of the two species are somewhat similar, but sufficiently different to warrant the separation" (*Baldwin*).

It is a local race of the highest peak of Mt. Lanaihale. The color-patterns of the type lot are shown in pl. 21, figs. 5, 6, 7. It is uniform orange-rufous with the tip of the apex pale, aperture pink; the same with a white subsutural band; or in addition to this there may be a white band or bands midway between the sutures on the spire, gradually deepening on the penult. whorl, to the ordinary ground-color.

In a series of 29 shells, collected by Mr. D. Thaanum, pl. 21, figs. 8 to 12, 5 are sinistral, the rest dextral. The sinistral shells have the color-patterns described above, the last whorl being uniform orange-rufous. Seven of the dextral shells are exactly similar in pattern to the sinistral, and they differ from *P. semicarinata* only by the deeper shade of color. Ten adult dextral shells are pale-yellowish flesh-tinted with several or numerous orange-rufous bands, varying in intensity among the specimens.

Embryo.—A dextral specimen of the typical orange-rufous color with white sutural band on the spire only, contained three embryos, two having a white sutural band, a white band a short distance below the suture and white columellar area, the other being multilineate with brown above and below. A dextral banded snail (pl. 21, fig. 10) contained 3 embryos, two 3-banded with some accessory lines, the other having numerous weak bands. In both examples the embryos are dextral.

It seems likely that the ancestral stock of *semicarinata* was banded, and typical *hayseldeni* is a more evolved form in which the banding has been replaced on the lower whorls or throughout by the dark color of the bands, while typical pale *semicarinata* has lost its bands entirely or on the later whorls. The whole series is so closely interrelated that I do not think it divisible into two species. I retain the name *hayseldeni* in a varietal sense because it is already in the literature, rather than from any real distinction, as I believe the intergradation with *semicarinata* is practically complete.

Section Baldwinia Ancey.

Baldwinia Ancey, Proc. Malac. Soc. London, iii, p. 270, July, 1899.

Shell sinistral (except in *P. dubia*), perforate, thin, ovate-acuminate or ovate-conic, with the color and sculpture of *Partulina;* lip narrowly expanded, but little thickened; columella somewhat twisted but *without a callous fold or tooth.* Type *A. physa* Nc., 1855 = *A. confusa* Sykes.

Baldwinia differs from *Perdicella* by its larger size and enlarged last whorl, giving the shell a conic form. It is no doubt, like *Perdicella,* a derivative of *Partulina,* which has the same sculpture and color-patterns.

It is quite likely that the Baldwinias of Hawaii, Maui and Oahu are so many independent derivatives from the *Partulina* stock, but until this is demonstrated it is simpler to group them together. In any case the forms of Hawaii and Oahu are in all probability the descendants of emigrants from the Maui-Lanai-Molokai center. Whether the degeneration of the columellar fold was expressed in the original stock is uncertain, since its degeneration is without doubt a secondary modification. The presence of Partulinoid forms in Oahu seems anomalous, but the distribution of *Laminella* and *Pterodiscus* also show that there was a limited amount of interchange between the Oahu and the Maui-Lanai-Molokai centers after the modern groups had become differentiated.

Species of Baldwinia.

1. Hawaiian species.
   - *a.* Aperture much more than half the shell's length; shell white or banded, without axial or oblique color streaks; surface smoothish, finely striate, last whorl much inflated. *P. horneri,* no. 47.
   - *a*¹. Aperture slightly more half the length; last whorl rather roughly striate; length over 20 mm. *P. confusa,* no. 46.
   - *a*². Aperture about half the length; shell variously banded or streaked, smoothish; densely striated spirally throughout, length less than 20 mm. *P. physa,* no. 48.

2. Mauian species.
   a. Last embryonic whorl finely zigzag-lineate; later whorls moderately convex. *P. grisea*, no. 49.
   a[1]. Last embryonic whorl obliquely striped; later whorls very convex. *P. thaanumiana*, no. 50.
3. Oahuan species. *P. dubia*, no. 51.

Mr. H. W. Henshaw, of Washington, D. C., well known as a trained and acute observer in several departments of science, has given the results of his studies upon this group in the following essay.

Observations on Hawaiian Achatinellidæ, by H. W. Henshaw.

"Although much has been written upon the *Achatinellidæ* of the Hawaiian Islands, comparatively little has appeared upon the habits of any of the species. During the early part of the year 1903 (January-April) the writer enjoyed unusual opportunities for making observations on the three species of *Partulina* inhabiting the Island of Hawaii, and the following notes pertain thereto.

" The peculiar interest attaching to these particular species lies in the fact that they occur only upon the Island of Hawaii, the youngest of the archipelago, that the three are specifically quite distinct from each other, that two of the three are, so far as known, absolutely restricted to limited sections of the northern end of the island, which is much the oldest, and that the third is found outside of this district only rarely. Thus, living in comparatively unoccupied regions and practically without competition, the three species offer an unusually favorable opportunity for a study of their habits, and especially of the method of their colonization and dispersal.

" Upon Oahu, the metropolis of the *Achatinellidæ* proper, there are so many closely-related species, several often crowded into the same area, that the facts relating to habits and means of dispersal are much complicated. An understanding of the manner in which the species of *Achatinella* form new colonies and of the laws of color variation in the group will

throw a flood of light upon the vexed question of specific relationship. The writer believes that a study of a carefully-selected series of the one hundred and more species of the Oahu Achatinellas by a student familiar with the local geographic conditions would reduce the number by at least one-half.

Partulina horneri Baldwin.

" This species, described in 1895 from specimens collected by Mr. J. Lewis Horner, appears to possess a present rather restricted range in the sparsely timbered region above Kukuihaele, Hamakua, and on the ridges above the Waipio and Waimanu valleys, an area of perhaps three or four square miles. Except for a few specimens obtained above Honakaa (on the doubtful authority of a Kanaka's statement) and Kukaiau (introduced or ' planted ' there by Eugene Horner) ten to twenty miles distant, this shell has never been found elsewhere. This restricted habitat, in a region where the competition is almost nil, represents all the territory the species has been able to acquire since the unknown date of its occupancy of the island. That the period of its occupancy has been considerable appears from the striking unlikeness of the species to all its congeners.

" Although occasionally living upon ohia (*Metrosideros polymorpha*), kolea (*Myrsine lassertiana*) and, rarely, upon kawaao (*Bryonia sandwichense*), the species is chiefly confined to a small berry-bearing tree called the ahakea (*Bobea elatior*) which is rather common at an altitude of 1,800-2,500 feet. This species, and in fact practically all the Achatinellas the writer is familiar with, is often found on half-dead trees, and not infrequently a thriving colony may inhabit a tree which boasts of but a handful of foliage. This appears to indicate that once a colony is established on a tree it persists, as long as it can obtain food, and I have found small colonies of shells on stubs of trees that apparently had been dead twenty-five or thirty years.

" This and the following species belong to the sub-genus *Baldwinia* of *Partulina,* and they are much more closely re-

lated to the shells of Molokai and Maui than to those of the more distant islands of the group farther north. It is highly probable, indeed, that the latter island furnished the parent forms, the channel separating the two islands being less than twenty miles wide. As species are reckoned in this group, the Hawaiian forms are distinct enough from any Maui shells, although the *A. physa* of Hawaii is rather closely related to the *P. grisea* of Maui, both in form and coloration, and the latter may have been the parent form, or at least descended from a common ancestor.

" The color of the typical and prevailing form of *A. horneri* is white with a broad zone of brown around the periphery, thence visible to the apex as a faint line above the suture. There is also, as noted by Mr. Baldwin, a pure white form of this species, and a third variety with only the apical whorls brown banded. To these is to be added a fourth color-variety, not previously noted, which is white save that the apex, for a varying distance, is tinged with brown. Of the four color forms, only the typical shell and the white variety are at all common; the other two are rare.

" There is some evidence to prove that formerly, even so late as ten years ago, the brown-whorled form was much more abundant than it is now, and many dead shells have been found on the heights between Waipio and Waimanu valleys where the living shells are very rare indeed (some living ones have been found by Mr. Thaanum).

" It is to be noted particularly that all the above forms of *horneri* occur in the same locality and on the same species of trees, but individual trees are never occupied by two forms. Moreover, with the possible exception of the banded form and the pure white one, the color varieties appear not to intergrade.

" As regards shape the four forms do not seem to differ appreciably. Roughly speaking there may be said to be a large and a small form of each of the four, but it is of interest to note that, while the individuals of each form intergrade in size, large and small forms do not live upon the same tree. The adult individuals on a tree are either all large or all

small. Thus the isolation of a few feet seems sufficient to permit recognizable changes both of size and color, though not of form.

" As these four color-forms occur in the same locality and are only to be distinguished by pattern of the shell, it might naturally be inferred that the embryonic young of the four would be of a common type, perhaps reverting in color to an ancestral form, and in any event not perpetuating the color peculiarities of their respective parents. The contrary is true. The young are not of a common type, but are always distinguishable *inter se*. Though markedly different in the adult state, there is less difference between the young of the white and the banded form than of the other two, but there is still a recognizable difference. The embryonic young of the pure white form retain the peripheral brown band of the typical *horneri* until about a third grown when only traces of it are discernible near the aperture and these finally entirely disappear leaving the shell pure white. The embryonic shells of the other two forms differ more markedly from each other and from the young of the other forms.

" The unlikeness of the respective young of several molluscan forms would appear to be an excellent criterion of their permanent distinctness, and the writer is inclined to view these two forms as far better entitled to specific rank than many named species of the group whose claim to distinction rests upon equally slight color characters supplemented, it is true in some cases, by present geographical separation of habitats.

" It is an interesting fact that the embryonic young of the brown-tipped form differ more from the young of the others than do the parent shells. The adult of the brown-tipped variety is to be distinguished only by the light-brown color of the apical whorls. The embryo shells have the lower half of the basal whorl of a deep reddish-brown. Evidently the brown tends to fade out as the shell matures. It is probable that in time the deep brown apex will become a permanent character of the adult of this form as it now is an invariable character of the young.

" It is probable enough, too, that in time the four color sports, if indeed two of them are not already properly to be ranked as species, will become completely isolated geographically when the present differences will be accented and perhaps further differentiation occur. No doubt many of the recognized species of the group have had origins and life histories essentially similar to the forms here noticed.

" How long these forms of *horneri* have been in reaching their present degree of differentiation cannot, of course, be told. Possibly they are nearly as old as the life of the species on this island; but in the case of creatures as plastic as the *Achatinellidæ* appear to be, probably no very long interval, nor very complete isolation, is requisite to establish such variations.

Partulina physa Newc. (*hawaiiensis* Baldwin).

" This shell was described by Mr. Baldwin from the same locality as the preceding, and its vertical range is about the same. It lives chiefly upon the smooth-leaved variety of the ohia but is found also of the kolea and casually on the haa (*Antidesma platyphyllum* Mann).

" Though this species varies much in coloration and size, there cannot be said to be any constant and well-defined color varieties, all the forms appearing to intergrade without limit. As in the case of the previous species, however, every colony, and sometimes the shells from individual trees within the confines of a colony, possess peculiarities of their own—slight differences of color and size, often sufficient to the eye of a trained collector to distinguish them from those of other colonies. The tendency to differentiate is the same in kind, but for some reason or other is has not progressed so far as in the case of *horneri*; possibly isolation has not been so complete as in the other species, although observation does not confirm this.

" The embryos of this species tend to follow the coloration of the parent form to some extent, especially when the latter are deep brown, but in most cases their colors do not indicate their parentage with any certainty.

" This species has been far more successful in extending its range than the previous one, and is found in three small and isolated colonies far beyond the confines of Hamakua, which probably was its starting point on the island. The *Partulina physa errans* from Olaa, Kaiwiki and Puna, from forty to sixty miles distant and separated by innumerable gulches and water-courses, is a derivative of this species if indeed, as the author believes, the variation is not entirely compatible with specific identity.

" The author has learned of a tree shell which many years ago lived abundantly on the ohias in South Kona, above and not far from Kealakekua Bay, and which now appears to be extinct there. If, as is probable from its description, this shell was *physa* (*hawaiiensis*), the species has nearly encircled the island of Hawaii, affording a marked contrast to the restricted range enjoyed by most of the species of this family, especially upon Oahu.

" It is to be remarked that this species, like the preceding, occurs chiefly in sparsely wooded districts and upon isolated trees. It is difficult to understand the wide dispersal of this particular species and especially its speedy appearance in clearings after the cutting of the forests, unless individuals exist here and there in the deep and virgin forest, where, however, the shell has never been found. Deep forest tracts appear to be inimical to the welfare, not only of the Achatinellas proper, but to almost all other Hawaiian land shells.

Partulina confusa Sykes (*physa* of authors).

" This species probably was formerly much more widespread in the districts of Kohala and Hamakua than it is to-day, owing to the present restriction of the forested area. It occurs at a higher altitude than the two preceding shells and extends at least as high as the upper edge of the Waimea Plains (3,500 feet) over most of which area it formerly occurred, although, like the preceding species, it is doubtful if it ever lived in the deep forest except casually.

" During the spring of 1903 the author had the opportunity of examining an isolated colony of this species on the Waimea

Plains, which for its extent and peculiar character deserves more than passing notice.

"The *P. confusa* lives chiefly upon the pua tree (*Olea sandwichensis*) although in some localities it has been found abundant upon the ilima (*Sida sp.*), a low shrub with yellow flowers. It occurs also upon the mamani (*Sophora chrysophylla*). Whether from the fact that the pua is not common over the island of Hawaii, or for some other reason, I did not find this shell, which is far more abundant than either of the other species, outside of the above region (Mr. D. Thaanum has found it widely spread in the Waimea plains).

"The colony in question occupies perhaps 150 pua trees, which cover an area of perhaps half a mile square, many trees being more or less widely separated from their fellows. The pua is a small tree fifteen or twenty feet high and with a small spread of branches. A rough estimate of the number of adult shells inhabiting this area when first visited is more than 75,000 shells, and it was possible to ride under the trees and from their trunks, leaves, and branches to pick shells literally by the handfuls. Cavities in the trunks and branches were usually packed with shells, mostly immature, from 50 to 75 being often found together. Wherever there were logs, dead branches or large rocks under the trees, they, too, harbored large colonies of shells, and the presence of young in numbers showed that these places were their permanent abode.

"In six hours, without climbing a tree, the author had no difficulty in gathering 1,100 adult shells, and his companion, Mr. William Horner, did the like—a statement which will sufficiently attest the abundance of the mollusks. The locality becoming known to several shell collectors, something like 10,000 adult shells were gathered in the course of three months without seriously diminishing the numerical strength of the colony. It is doubtful if so many tree shells of any one species were ever found in a like area, even in the Hawaiian islands, abundant as the Achatinellas are, or used to be, in some places.

"The colony in question comprised numerous color varie-

ties and the shells differ much in shape. Mr. Horner, of Kukuihaele, has succeeded in selecting from several thousand no fewer than 200 and odd more or less distinct varieties. For the present purpose of the author it will suffice to enumerate a few only of the more marked forms in the author's own collection.

" 1. Uniform light gray, with or without faint brown markings on apical whorls.

" 2. Distinct brownish-gray with more or less distinct markings on apical whorls. Undoubtedly these two forms, the second being but a slight variation of the first, are to be considered as the typical ones of the colony; at a rough guess one-half of all would come under one or the other.

" 3. Dark brown, almost chestnut, with lighter colored apical whorls; lower whorl sometimes with, sometimes without, gray spots.

" 4. Light gray with broad or narrow light-brown band across body whorl.

" 5. Light gray with broad white band across body whorl, bordered with narrow brown band.

" 6. Light gray, more or less streaked and spotted with brown; a distinct white band on body-whorl bordered by a chestnut band.

" 7. Light gray, with chestnut body-whorl bordered above and below with white.

" 8. Many-banded with alternate bands of brown and white from apex to base, some narrow, some broad.

" 9. Dwarfed and somewhat distorted form, running through all the above variations, and found only on mamani trees (*Sophora chrysophylla*).

[Plate 16, figs. 2 to 12, represent shells from this colony.]

" The exact size and shape of the above varieties vary almost interminably and, it is perhaps needless to say, intergrade with each other completely.

" The above brief notes afford but little idea of the great variety and apparent distinctness of some of the color forms. Many species of the genus *Achatinella* appear in printed lists which are based upon color characters much less marked than

those which distinguish this series. The number of forms might be multiplied almost indefinitely, but the above will suffice to indicate the general character of the variations existing within this single colony.

"As in the case of *P. horneri,* a distinct tendency is observable, though by no means so marked, to the segregation of the different color varieties upon individual trees, indicating that isolation has been sufficient to permit differentiation within certain limits, while the fact that many trees support a sprinkling of other varities, added to the completeness of the intergradation, proves that intercommunication has been to some extent potent in limiting the amount of the divergence.

"The following facts bear upon the question of intercommunication between the several parts of the colony. The pua and mamani trees, upon which the shells live, rarely touch each other, and are usually separated by a distance varying from a few feet to a hundred yards. The land is pasture and the grass under many of the trees—not in the open—is deep. There is thus no chance for the shells to pass freely from tree to tree.

"Upon Oahu and the other islands of the group deep valleys and high ridges in most localities tend to the more or less complete isolation of shell colonies, and also present diverse conditions of foliage and environment favorable to the differentiation of new forms. The environment of the present colony on the contrary is exceedingly uniform and hence presumably unfavorable to the origin of new varieties, but the isolation of the trees and the open nature of the ground form barriers to free intercourse quite as effective as ridges and valleys, and hence tend to the perpetuation of any chance varieties that may arise.

"The author is aware that some observers consider the *Achatinellidæ* to be active and rather extensive travelers, but his study of the three species under consideration points to the opposite conclusion. The fact, as noted above, that logs and rocks under the trees form the permanent abode of such shells as chance to fall from above, seems to show that the

shells from some cause are unable to find the way back to the tree on which they were born though but a few feet distant. A favorite resting place of the Achatinellas is on the under side of leaves, especially dead leaves, and as these fall or are blown off by high winds they naturally carry the shells with them—usually to the ground immediately beneath the tree. In a number of instances shells that had shaken from the tree into the grass from six to twelve feet away from the trunk were found where they had fallen several weeks later, being apparently quite lost. That Achatinellas can travel twelve or fifteen feet over a tree in a single night there can be no doubt, since the author has observed them in the act and has measured the distance traveled; no doubt they are able to travel much farther than this, as certainly can the Amastras and the apparently still weaker Succineas. It seems likely, therefore, that natural sluggishness or defective vision, perhaps both, are responsible for the failure of such shells as fall or are blown from trees to find their way back to the parent trunk. Whatever the explanation, the fact that the three species of Achatinellas here considered are as a rule very sedentary and rarely or never regain their place on a particular tree when once dislodged seems to the author indisputable.

"The question then arises as to the means of dispersal from tree to tree and from locality to locality possessed by shells under conditions similar to those here indicated. The author is convinced that the dispersal of the three species here mentioned is effected chiefly through the agency of wind when the shells are young. In several instances he has found a single young *Partulina,* but a few days old, to be the sole occupant of a shrub or tree (so small as to be readily examined leaf by leaf) separated several hundred yards from the nearest shell-bearing trees. In such cases no other transporting agency suggests itself but the wind or birds.

"It would require a considerable gale to carry to a distance a leaf laden with an adult *Achatinella,* but a very moderate wind would suffice to carry a leaf with a young one which weighs but a gramme or two for a considerable dis-

tance. An adult shell once upon an isolated tree, one that is separated from its fellows even by a few yards, might live and die leaving its progeny, if it chanced to be pregnant, to perpetuate its peculiarities, subject only to the modifying influences of such individuals as by rare chance might be blown to the same tree.

"Where shell-inhabited trees of the same species interlock branches a more or less free interchange of inhabitants would naturally take place, limited only by the natural sluggishness of the mollusks, and, as a matter of observation, the forms of *P. confusa* inhabiting closely adjacent pua trees were found to be practically indistinguishable.

"As bearing upon the problem of the variation of this species, a most suggestive fact was noticed in connection with the colonies upon the mamani trees. This is a small-leaved, leguminous tree, and in appearance, and no doubt in fact, is not well adapted to molluscan life. Yet generally where the mamanis adjoined the pua trees, and invariably where they touched branches, the mamanis were found to be occupied by colonies of *confusa*. These shells were almost always smaller than those of the neighboring pua trees, often had diminutive and distorted spires, and in every external aspect suggested the effect of insufficient food or of unfavorable conditions of life. Whatever the explanation, the change of habitat from one species of tree to another closely adjoining has resulted in establishing a recognizable form, striking evidence of the plasticity of the *Achatinellidæ*, and of the slight nature of what seem to be insurmountable barriers to free intercourse between separate, but closely adjoining, molluscan colonies.

"An examination of the embryonic shells of *confusa* discloses that in a few of the more strongly marked forms the embryo tends to perpetuate the color peculiarities of the parent. Thus the young of the gray form are like their parents, and are almost destitute of the zigzag markings which decorate the spires of almost all the forms, but are often wanting in adults of the gray variety. So, too, the young of the brown shell, with brown and white body band, are often but not always marked like their parents. But it would

be impossible to determine with any degree of certainty the parentage of the greater number of embryonic shells of this species from their appearance alone—whether they came from banded, multi-banded, or unicolored shells. Clearly the color varieties are not yet fully established.

" It is well known that many of the species of the *Achatinellidæ* are indifferently dextral or sinistral. Some, however, are consistently one or the other, and the *P. confusa* belongs in the latter class. Among upwards of ten thousand individuals of *confusa* examined, not a single dextral shell was found.

" Most of the *Achatinellidæ* proper, as is well-known, dwell upon trees and the greater number of individuals of the several species pass most of their time upon the leaves, feeding and moving about only by night and, to a very limited extent, on dark and rainy days. A certain amount of moisture—apparently the more the better—seems indeed necessary to their mode of progression, if not to their very existence, and in dry weather they are strictly sedentary.

" The three species in question dwell indifferently upon the trunk, the branches, and the leaves of trees, though in day time the greater number are attached to leaves. As a rule they appear to be very sluggish and often remain for weeks, especially when young, attached to leaves and branches without moving and apparently without eating. Individuals in captivity have been known to live a couple of months without food or water, which argues the possession of considerable vitality. Under such circumstances adult shells are known often to give birth to apparently healthy young.

" Unlike the Amastras and the Succineas, the *Achatinellidæ* proper do not appear to feed upon the chlorophyl of leaves; at least the leaves upon which the shells are found seem never to show visible signs of their work. The two former groups consume leaf tissue voraciously, both dead and living foliage, and often leave them completely skeletonized. Both of these groups live also no doubt to a considerable extent on fungi, as they are often found upon dead wood. Indeed the presence of *Succinea* in numbers upon coffee trees,

for instance, is a pretty sure sign that the trees are no longer in a healthy condition.

"With a view to determining the nature of the food of *A. confusa,* the writer with the assistance of Dr. Nicholas Russel, examined microscopically the feces of a number of individuals. In only two instances were minute particles of chlorophyl found and these, perhaps, were accidental. The great mass of the remains appeared to be of minute fungi or algæ.

"To what extent the fungus-eating habit prevails throughout the *Achatinellidæ* remains to be determined by future observations, but from the fact that many other species are known to reside upon dead trees, or upon the dead branches of living trees, it may be presumed to be somewhat general if, indeed, fungi be not the main reliance of the family. In connection with the food of the Achatinellas, it is of interest to note that in a number of instances small but apparently thriving colonies were found on dead stubs which had not borne a green leaf for years, perhaps twenty or more. It would seem that under such circumstances fungi must be the sole dependence of the shells. As such stubs are often within a few yards of living trees of the same species, there would at first sight appear to be no reason why the colonies did not abandon the trees after they died and make their way to other trees. Apparently, however, the mollusks either do not care to migrate even a short distance, or are incapable of doing so. In any event, their isolation, whether voluntary or involuntary, is complete, and successive generations of mollusks live and die on the same tree where they were born, even after the latter perishes and until it finally crumbles away.

"The ability of the Achatinellas to maintain life for considerable periods without food, and to found colonies and live indefinitely upon dead trees, greatly favors their chances in the struggle for existence.

"Many experiments have been tried from time to time in transplanting the Achatinellas from one locality to another and even from island to island, but in no instance known to the author have they been successful. The writer experi-

mented in this way with the three species here mentioned, removing perhaps a hundred individuals, old and young, from an altitude of between 1,600 and 3,000 feet to about 800 feet above and near the sea, where they were placed upon a magnolia tree. The chances of the colony surviving such a complete change of environment seemed very small. Nevertheless for a short time the shells seemed to thrive, but they were discovered by rats and the colony was soon exterminated.

" Great numbers of Achatinellas, as well as Succineas, in their natural habitat on the several islands are destroyed by rats and mice, and the extermination of many of the species is now being hastened by these agencies.

" An Achatinella which Mr. D. D. Baldwin refers to *Partulina physa* (= *confusa*) was found by the writer abundantly in the semi-fossil deposits closely adjoining the colony of that shell above described. The great size of this fossil leads to a first impression of its distinctness from *confusa*, but a careful comparison of many specimens constrains the writer to adopt Mr. Baldwin's view, since, as remarked by that veteran conchologist, a description of the fossil would read precisely like that of *confusa* save in respect of size.

" Tables are appended which indicate the degree of prolificness of the species here treated of. The season when the shells were collected (January-April) was unusually cold and stormy, and perhaps in mid-summer different ratios might be had, although Mr. Thaanum. who has dissected many Oahu species with reference to the number of young, tells me that he has never noted much if any seasonal difference in this respect, the shells bearing young the year round.

" In several of the forms the number of shells examined is too small to give results of much value. In the case of the brown-whorled *horneri*, for instance, a greater number would doubtless materially reduce the average number of young per adult shell."

	No. adult shells.	No embryos.	1 embryo.	2 embryos.	3 embryos.	4 embryos.	5 embryos.	6 embryos.	Average no. embryos in fertile shells.
P. physa (*hawaiiensis*) . .	247	47	148	44	4	4	. .	. .	1.32
P. horneri, brown banded variety	16	2	3	3	6	2	. .	. .	2.5
P. horneri, white variety.	33	16	5	4	5	3	. .	. .	2.35+
P. horneri, brown whorled variety	10	1	. .	1	3	3	1	1	3.77+
P. confusa	149	50	59	24	16		. .	. .	1.5

46. P. CONFUSA (Sykes). Pl. 16, figs. 1 to 12.

"Shell sinistral, pointed at the summit, strongly inflated below, rudely striated obliquely. Whorls 6, first five flatly convex, the last largely inflated and obsoletely carinated. Suture simple and deeply impressed. Columella short, slightly callous, broad, and partially covering a deep umbilicus. Aperture large, semiovate; lip subreflected below, thin and simple above. Color of a dingy white, occasionally marked with yellow flammules, internally of a light-lemon yellow. Length 18, diam. 12-twentieths of an inch" (*Newc.*).

Hawaii (Newcomb); Kohala (Baldwin); near Mana, Hamakua (Thaanum); Waimea plains; a very large form in fossil deposits of Mana (Henshaw); Waimea side of Kohala Mts. (L. A. Thurston).

Achatinella physa NEWCOMB, Proc. Boston Soc. Nat. Hist., v, p. 218, September, 1855; American Journ. Conch., ii, p. 214, pl. 13, f. 10, 1866.—BALDWIN, Catalogue, p. 7 (Kohala); Proc. A. N. S. Phila., 1895, p. 225 (animal).—THWING, Reprint Orig. Descript. Achat., pl. 2, f. 21.—HENSHAW, Journal of Malacology, xi, p. 57, 63, Sept., 1904.—*Achatinella* (*Partulina*) *confusa* SYKES, Fauna Hawaiiensis, ii, p. 312, 1900, based upon *A. physa* Newcomb, Sept., 1855.—*Partulina*

physa Newc., var. *phœostoma* Ancey, Proc. Malac. Soc. London, vi, p. 121, June, 1904.—*Achatinella physa* Newc., var. *procera* Ancey, Journ. of Malacol., xi, p. 69 (Palihoukapapa, in fossil bed).

Doctor Newcomb's second description is reproduced. I believe with Mr. Sykes that Newcomb's first description and figure (pl. 17, fig. 6) of *A. physa* (1854) pertain to the form subsequently called *A. hawaiiensis,* which he took to be the young stage of the larger shell which he afterwards (1855) obtained and later figured as *A. physa.* One lot in the Robert Swift collection (A. N. S. P.) at least 50 years old, received from Newcomb, contains two "*hawaiiensis*" with others of the large form like Newcomb's figure of 1866. Dr. C. Montague Cooke and Mr. Thaanum, who have gone over the evidence and figures with me, agree in this interpretation of Newcomb's *A. physa,* confirming the opinion of Mr. Sykes.

The first whorl of the embryo is smooth; subsequent whorls are finely striate spirally. The first two whorls are creamy-brownish, after which there are zigzag brown flames (fig. 12). These may continue as far as the middle of the fifth whorl, but they usually disappear earlier. In other embryonic shells there is a brown band just below the periphery, followed by a white band (fig. 11). These persist in the adult shell to the end. In a number of examples with uterine young sent by Mr. Thaanum, the young shells of one parent are not diverse, but in every case agree with the mother in pattern. These observations have been confirmed by the examination of large series in Mr. Thaanum's collection. The periphery is acutely carinate and the columella is sinuous in embryo shells at all stages examined.

On the last whorl of the adult shell the crowded spiral lines of the early stages become weak, often almost obsolete, and wide apart. The color varies as shown in the figures and described below. The columella is brown or white, nearly straight or somewhat sinuous. Umbilicus half open or more.

Length 26, diam. 17, aperture 14 mm.; 6⅓ whorls.

Length 26.2, diam. 15.5, aperture 12.8 mm.; 6½ whorls.

Length 26.3, diam. 16, aperture 14 mm. (near Mana).

Length 23, diam. 15.2, aperture 12 mm. (near Mana).

Length 23, diam. 13.8, aperture 11.2 mm. (near Mana).

Length 27.7, diam. 17.5 mm. (Mana, Bishop Mus., no. 22357).

Var. *phœostoma* Ancey. " Shell glossy, pale coffee colored, the apex white, posterior part tessellated, marked with close spiral lines and rough growth-striæ. Aperture and columella brown, throat glittering, brown, the edge a little paler. Length 23, diam. 14.5, oblique length of aperture 11.5 mm. Hawaii, Thaanum " (*Ancey*). The type of *phœostoma*, now in coll. Bishop Museum, shows no racial characters whatever to differentiate it from *confusa*, and I do not think it a valid variety or race.

" Var. *procera* Ancey " was never defined in any way, but one may infer that Mr. Ancey's intention was to name the large fossil form of the Palihoukapapa bed.

Hon. L. A. Thurston collected a series of *confusa* on the Waimea side of the Kohala Mts., including some shells darker than any from localities farther east.

47. P. HORNERI (Baldwin). Pl. 17, figs. 1 to 5.

" Shell sinistral, minutely perforated, thin, globose with a short acutely conical spire, apex acute; surface shining, striated with fine incremental lines, and under a lens exhibiting very close and delicate decussating spiral striæ; embryonic whorls faintly cross-lined. Color dull white, encircled at the periphery with a faint brown zone which is continued on the suture, also with a very small patch of same color around the umbilicus. Whorls 6, the upper five slightly convex, the last very much inflated, forming the greater part of the shell; suture distinctly impressed. Aperture oblique, sub-rotund, very large, white within, distinctly showing the external peripheral band; peristome margined with light brown, rather thin, very slightly thickened within, expanded, basal and columellar margins narrowly reflexed, extremities slightly converging and united by a thin callus; columella light brown, very slightly developed, plain and smooth. Length 24, diam. 18 mm.

"Animal in motion longer than the shell. Mantle black, margined with gray. Foot above and below gray, the superior portions lightly granulated. Tentacles light gray" (*Baldwin*).

Hawaii: Above Kukuihaele, Hamakua, type loc.; ridges above the Waipio and Waimanu valleys; above Honakaa and Kukaiau (see p. 92). Fossil in the Mana deposits.

Achatinella horneri BALDWIN, Proc. A. N. S. Phila., 1895, p. 224, pl. 10, figs. 20, 21, 22.—HENSHAW, Journ. of Malac., xi, p. 63.

Distinguished from *P. confusa* by its shorter spire, much more inflated, broader last whorl, and the less roughened, more even and shining surface. Moreover, the embryo has no zigzag-striped stage. Named in honor of Mr. J. Lewis Horner. The following color-races are found.

(*a*) Pl. 17, fig. 1. White, with a brown band at the periphery, ascending the spire in a narrow line above the suture. Size large, length 23.5, diam. 18, aperture 14.6 mm.; 6 whorls.

(*b*) Pl. 17, figs. 2, 5. Brown, with a narrow white band below the suture, one above, another below the periphery. The brown fades on the penultimate or on the last whorl, which in large part or entirely is white. 23 x 16.4 mm.

(*c*) Pl. 17, figs. 3, 4. White, with a pale brown band immediately below the periphery, which fades out on the fifth whorl, being visible therefore only in immature shells, the adult stage pure white throughout. Embryo ivory-white with a distinct brown subperipheral band. 22 x 15.5 mm. Above Kukuihaele, Hamakua.

(*d*) Young stage light brown, darkest just below the periphery; adult white with pale brown spire. Embryo bicolored, pale brown above, darker brown below the periphery. 20.5 x 15.5 mm. Above Kukuihaele.

These several color-forms are evidently incipient races, as they occur in pure colonies, so far as known. Races *c* and *d*, Mr. Thaanum informs me, occur three or four miles apart. The embryonic forms are much more distinct than the adults, and are constant in the colonies.

By the loss of zigzag stripes on the embryo and young

stages, this species is more evolved than other Hawaiian Baldwinias.

48. P. PHYSA (Newcomb). Pl. 17, figs. 6 to 13.

" Shell sinistral, acutely conical, thin, inflated. Whorls 5, rounded; suture well marked. Aperture widely ovate; columella thin, slightly twisted; lip simple. Color light yellowish brown with white longitudinal flammules, with or without a subcentral revolving white line on the body-whorl. Length 11, diam. five-twentieths of an inch " (*Newc.*).

Hawaii: Mauna Kea (Newcomb); Hamakua (J. Lewis Horner); Waimea Plains, Hamakua. Chiefly on dead trees but sometimes on living lehua (D. Thaanum).

Achatinella physa NEWC., P. Z. S., 1853, p. 152, pl. 24, f. 64, 1854.—SYKES, Fauna Hawaiiensis, Mollusca, p. 316.—*Achatinella hawaiiensis* BALDWIN, Proc. A. N. S. Phila., 1895, p. 225, pl. 10, f. 24-26 (Hamakua).—GWATKIN, t. c., p. 238 (radula).—THWING, Reprint Orig. Descript. Achat., 1907, pl. 2, f. 22.

Smaller and less roughened than *P. confusa,* and differing in coloration. Some shells have very much the pattern of the young stage of *confusa.* Newcomb's original description and figure (copied in pl. 17, fig. 6) are given above. *A. hawaiiensis* Baldwin is figured from the type lot sent by Mr. Baldwin, pl. 17, figs. 7, 8, 13. It is believed by Mr. Sykes to be identical with Newcomb's original *A. physa,* an opinion in which I agree, having gone over the matter carefully with Dr. Cooke and Mr. Thaanum.

A. physa varies widely in color-pattern, as follows:

(*a*) White, with brown oblique or zigzag streaks above a narrow peripheral brown band, and having a broad brown zone on the base (pl. 17, figs. 7, 8).

(*b*) White, with more or less brown on the spire, the peripheral brown band and basal zone more or less interrupted (fig. 13).

(*c*) Brown, indistinctly mottled and streaked with cream-color, with a subperipheral band of the same or of white (fig. 9).

(*d*) Brown, with subperipheral white band, and zigzag white stripes more or less developed (figs. 10 to 12).

Specimens more or less intermediate in pattern connect these forms, which (figs. 9 to 12, Waimea Plains) live together in the same colonies. Pattern *d* changes to a streaked pattern on the latter part of the last whorl in adult shells (fig. 12). The embryonic shell is like that of *P. confusa* in form except that the columella is more strongly convex. It is marked with broad vertical stripes of cream-white and brown, their edges irregular or zigzag.

Length 19.7, diam. 12, aperture 9.8 mm.; whorls 6¼.

Length 18, diam. 10.2, aperture 9 mm.; whorls 6.

Length 17, diam. 10.5, aperture 9 mm.; whorls 6.

The original description of *A. hawaiiensis* follows.

"*Achatinella hawaiiensis.* Shell sinistral, minutely perforated, very thin, acutely conical, apex acute; surface rather lusterless, covered with fine lines of growth, and under a lens showing extremely close and delicate decussating spiral lines; nuclear whorls faintly decussated. Color very variable, plain brown or dingy white, sometimes irregularly striped or mottled with brown and white, the base generally uniform brown, but sometimes with undulating markings of brown and white; the only constant characters being a brown, sometimes interrupted, line at the periphery, bordered below with a broader white line. Whorls 6, slightly convex, the last inflated. Suture lightly impressed. Aperture oblique, oval, brown, the peripheral brown and white bands distinctly marked within. Peristome acute, not thickened within, external margin straight, basal expanded, the expanded portion being very thin and fragile, the columella margin reflexed over the minute perforation; color white on both face and the reverse. Columella white, very slightly developed, plain and smooth. Length 18, diam. 10½ mm.

"Animal when extended in motion longer than the shell. Mantle almost white, margin of a darker shade. Foot above and below dingy white, superior portion sometimes flecked with gray. Tentacles of darker shade. The dentition is the same as that of the arboreal Achatinellas generally. A cen-

tral tooth is present; and the formula of dentition is 125-1-125 × 120 = 30,120." (*Baldwin*).

48*a*. P. *physa errans,* n. var. Pl. 17, figs. 14, 15, 16.

The shell is thin, sinistral, more slender than usual in *P. physa* (*hawaiiensis*), minutely perforate or almost imperforate, smooth and slightly shining, under a lens minutely marked with growth-lines and closely, distinctly striate spirally throughout, the striæ rippled. Embryonic shell marked with broad axial brown stripes as in *P. physa*; neanic whorls marked with brown zigzag stripes on a white or cream ground; on the last whorl the stripes are usually interrupted by a light band below the periphery, and are irregular on the base. Sometimes the brown markings are very faint. The whorls are rather strongly convex. Aperture varying from purplish-brown to faint pink within; lip thin, very narrowly expanded, white-edged within. Columella reflexed as in *P. physa.*

Length 18, diam. 10.8, aperture 9.2 mm.; whorls 6.

Length 18, diam. 11, aperture 9.8 mm.

Length 16, diam. 9, aperture 8 mm.

Near Pahoa, Puna, type loc., fig. 14, and Kaiwiki in the district of South Hilo, figs. 15, 16 (Thaanum).

This very beautiful form was thought by the late Mr. Baldwin to be distinct from his *A. hawaiiensis,* but Mr. Thaanum agrees with us that it may more justly be ranked as a subspecies. It is separated by innumerable gulches and water courses from the range of *P. physa,* some forty to sixty miles distant, but the intervening territory has not yet been fully searched; still there can be no doubt that the range of *errans* is discontinuous with that of *physa.* In Puna it has reached the extreme southeastern range of *Achatinellidæ.*

In Olaa Mr. Thaanum found *P. p. errans* in ieie heads.

49. P. GRISEA (Newcomb). Pl. 18, figs. 8, 9.

"Shell sinistral, inflated below, pointed at the summit; whorls 6, rounded, not margined. Aperture ovate; columella short, flat and but slightly twisted; lip expanded, thickened

within. Suture well impressed; umbilicus open. Color above grayish-white mottled with light brown, below ashy-gray; the body-whorl encircled by a narrow white band. Length 16, diam. nine-twentieths of an inch " (*Newc.*).

Maui: Makawao (Newcomb, type loc.).

Achatinella grisea Newc., P. Z. S., 1853, p. 153, pl. 24, f. 66.—Pfr., Monogr., iv, 518.—*A. dubia* var. *b* Pfr., Malak. Bl., 1854, p. 117.

The conic spire rather slender above, and the weak columellar fold give this shell somewhat the contour of *A. physa* Nc. of Hawaii. After the smooth first whorl, two are very closely and *deeply striate* spirally. The spirals become weaker on the last whorl. 1½ apical whorls are pale brownish white. Then broad, irregularly zigzag brown stripes usually appear, and on the last embryonic whorl a dense pattern of narrow zigzag lines (pl. 18, fig. 8). After 3½ embryonic whorls the neanic pattern of oblique streaks sets in. These become zigzag or irregular on the later whorls. The last whorl is perforate, narrowly banded with white, dark fawn color below the band. In two specimens I have seen there is no band. The aperture resembles that of *P. dwightii* except that the lip is far less thickened and the columella moderately twisted with no callous fold superposed upon the convexity. Figures are from Makawao shells received from Newcomb.

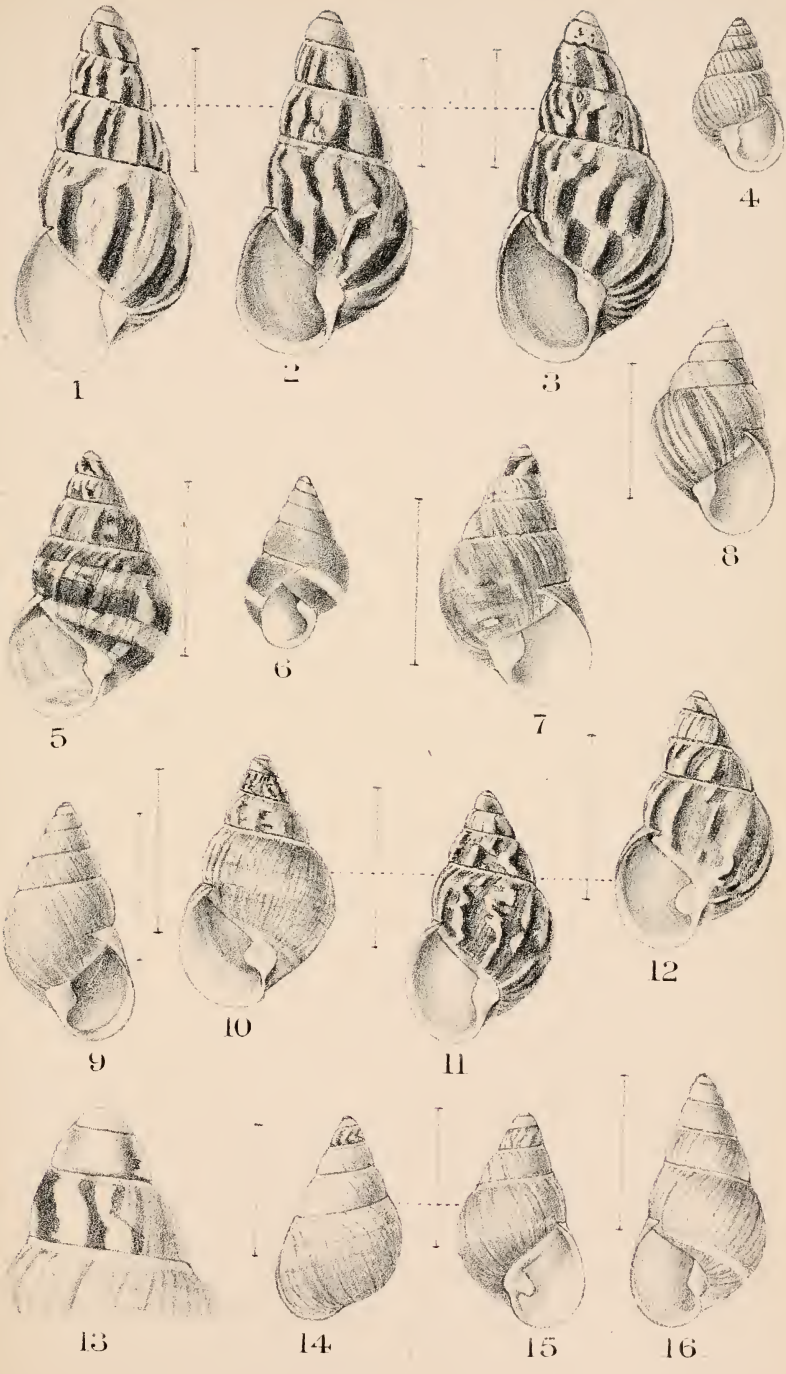
Length 20, diam. 11.5 mm.

Length 21.2, diam. 12.5 mm.; whorls 6⅔.

P. grisea is not closely related to any other Mauian snail, but it has much in common with *P. dwightii* of Molokai, the shape of the spire, pattern and color being nearly alike in the two species. The pattern of the last embryonic whorl is different, and *P. dwightii* has a stronger columellar fold. It is one of the rarest Mauian shells, and as yet entirely unknown to Hawaiian conchologists of the present day, although the Makawao district has been thoroughly worked over. It may be extinct.

50. P. thaanumiana Pilsbry, n. sp. Pl. 18, figs. 6, 7.

The shell is sinistral, narrowly umbilicate, *thin*, ovate-conic,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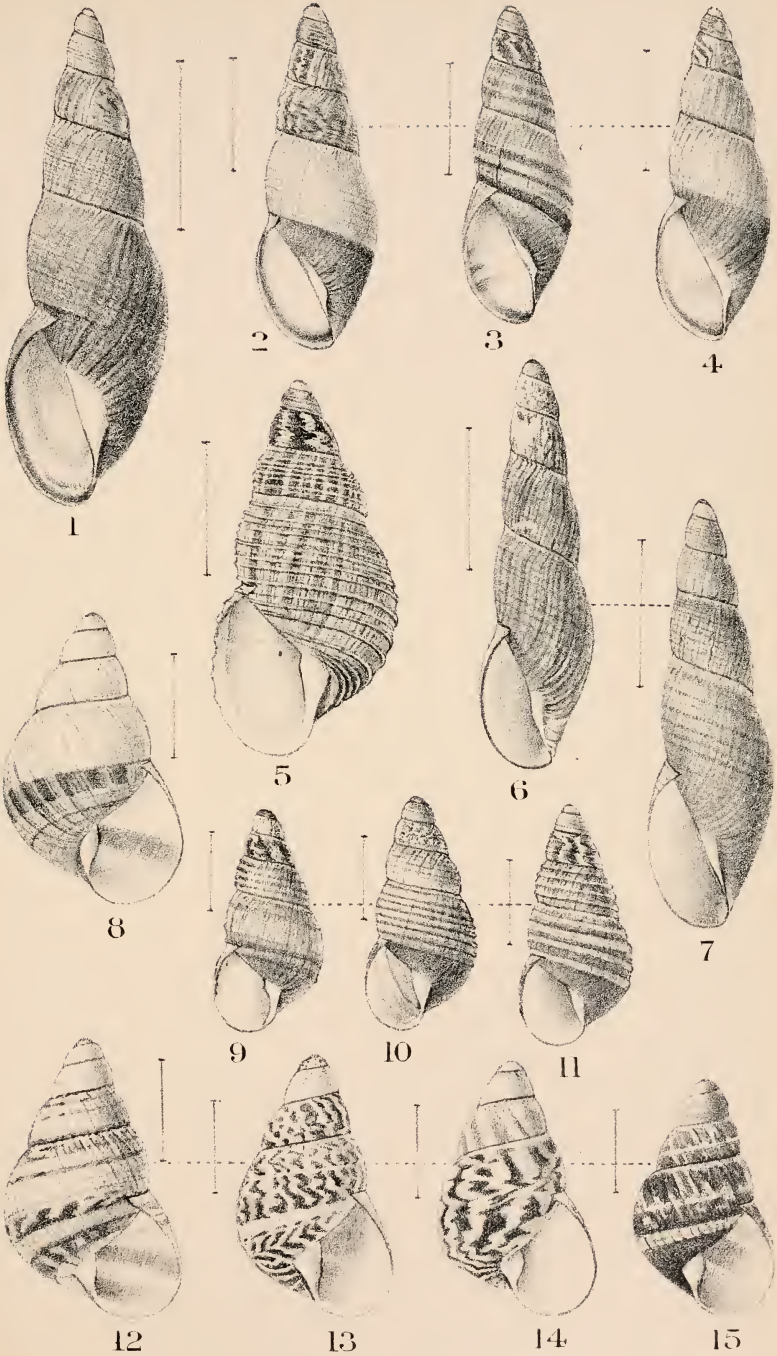
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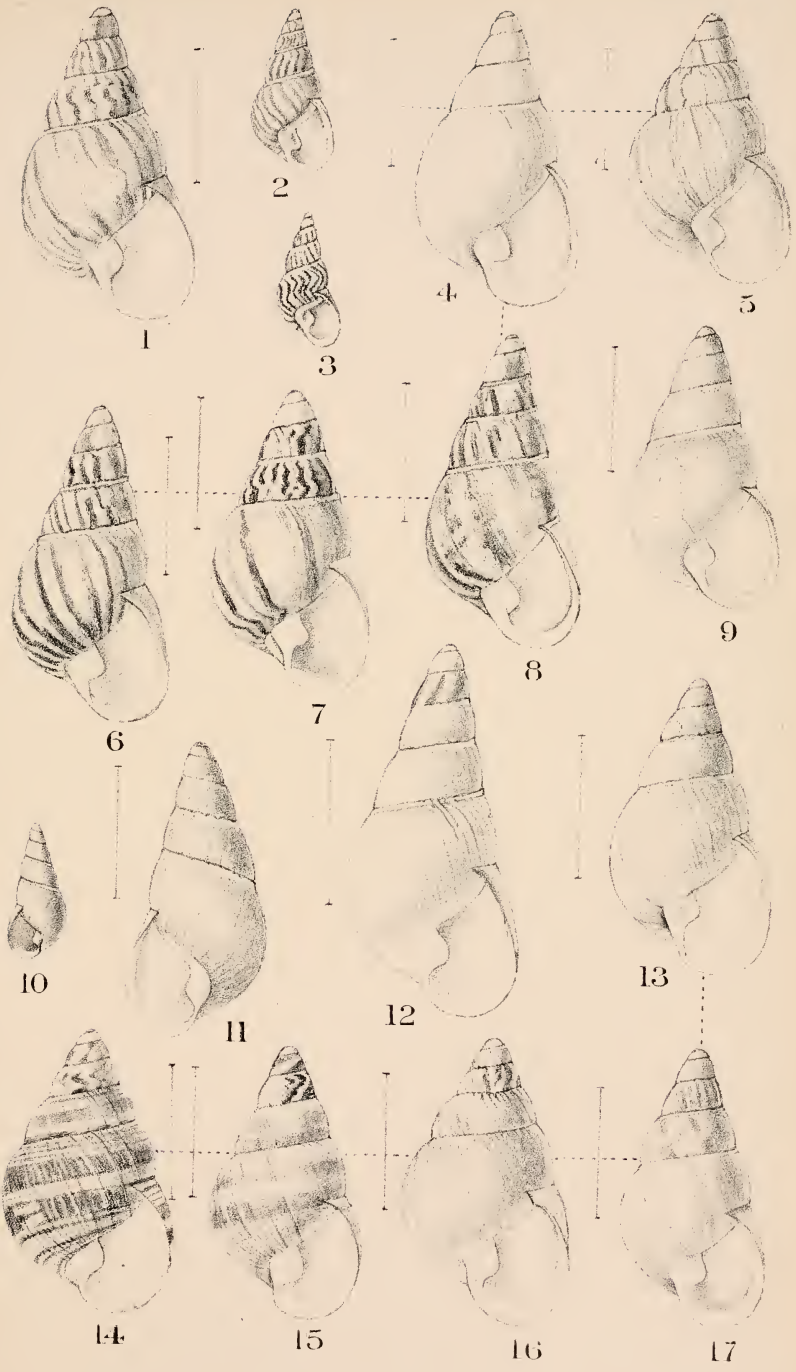
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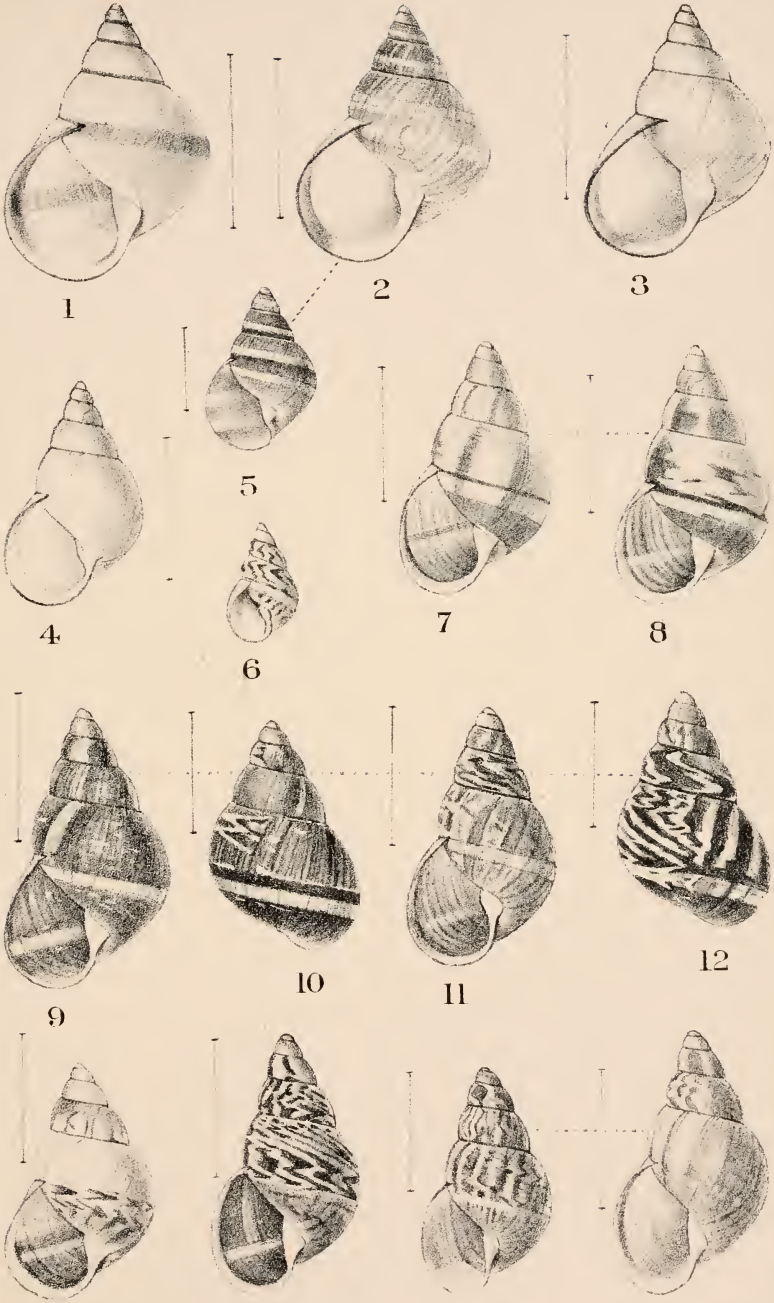
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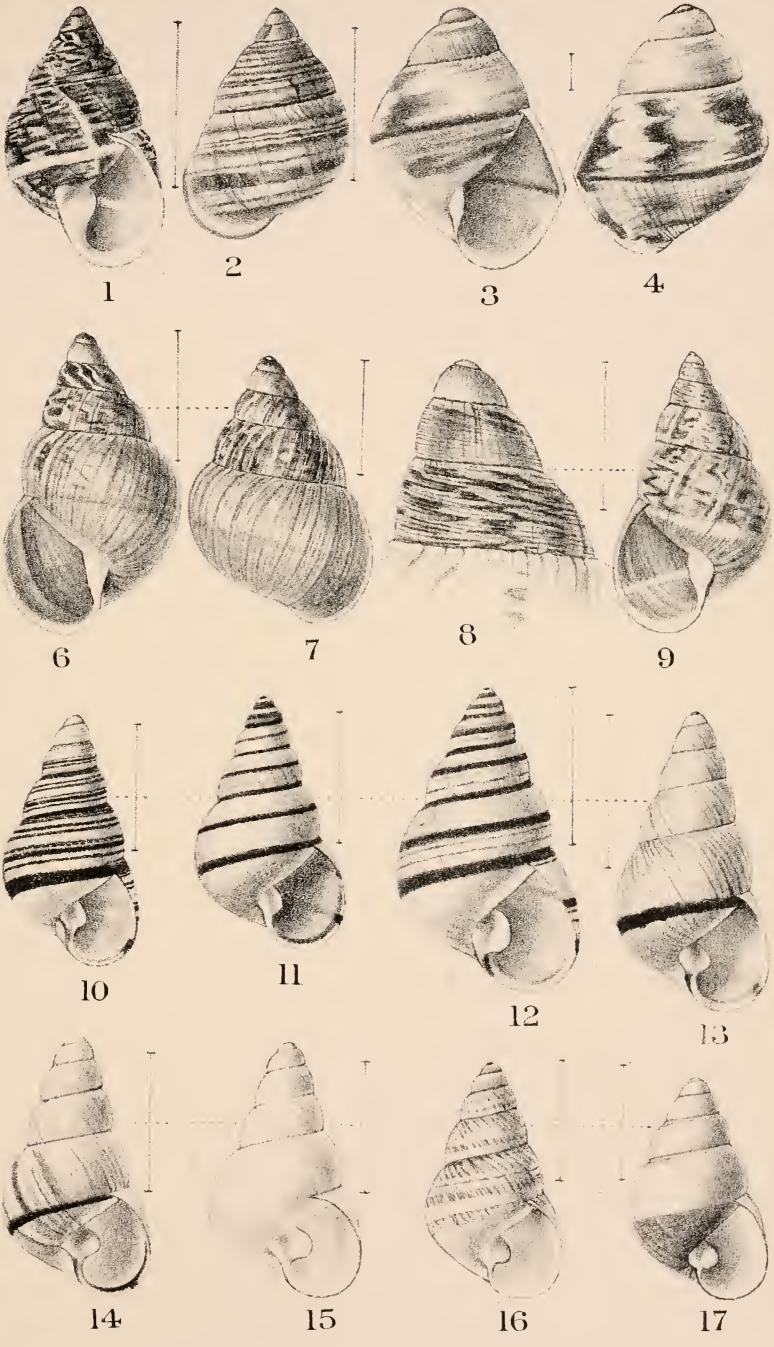
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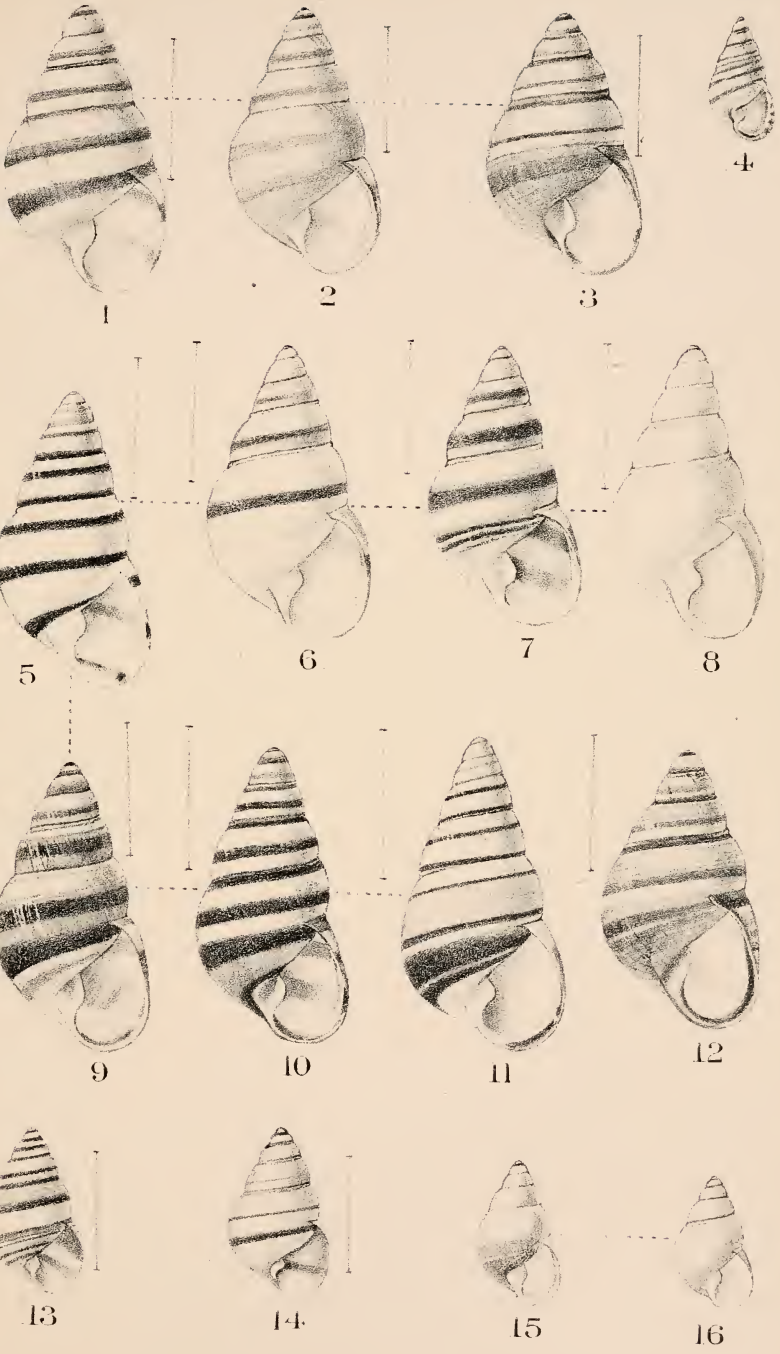
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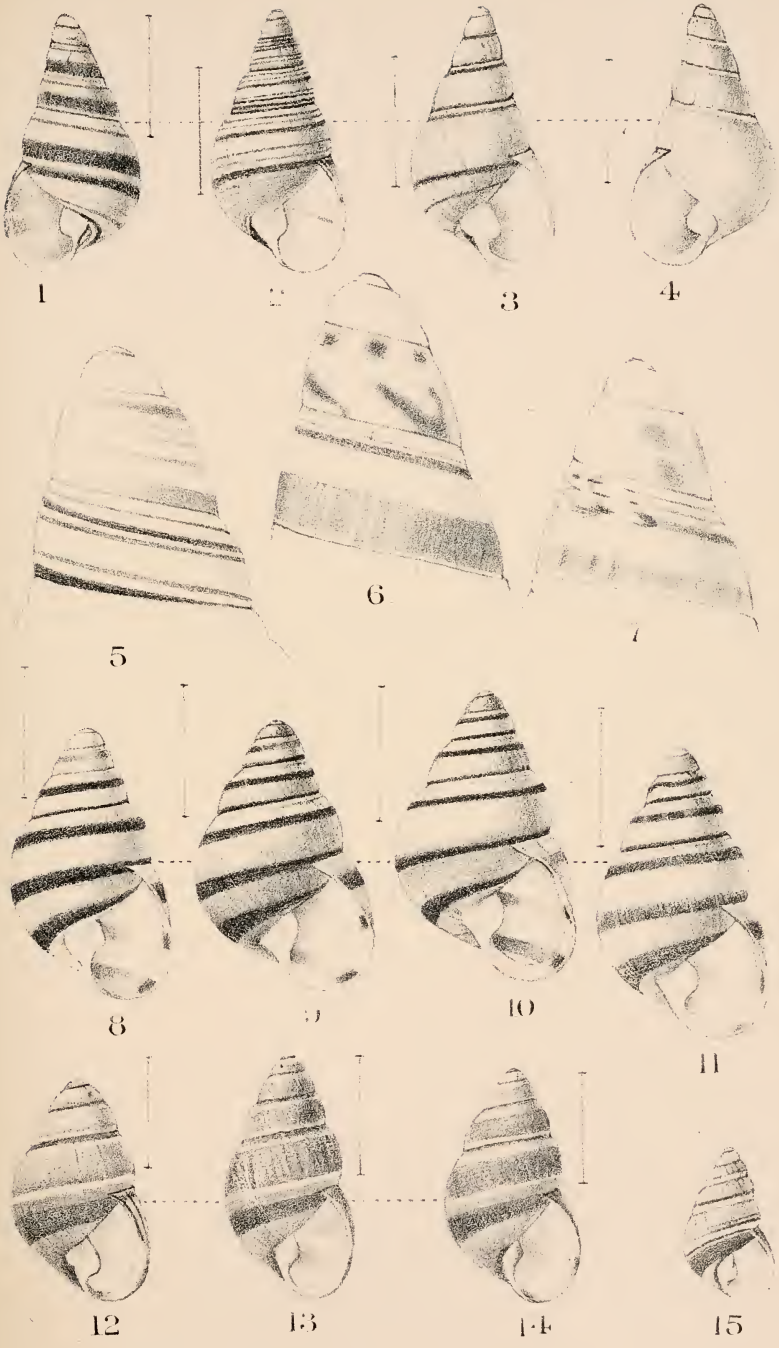
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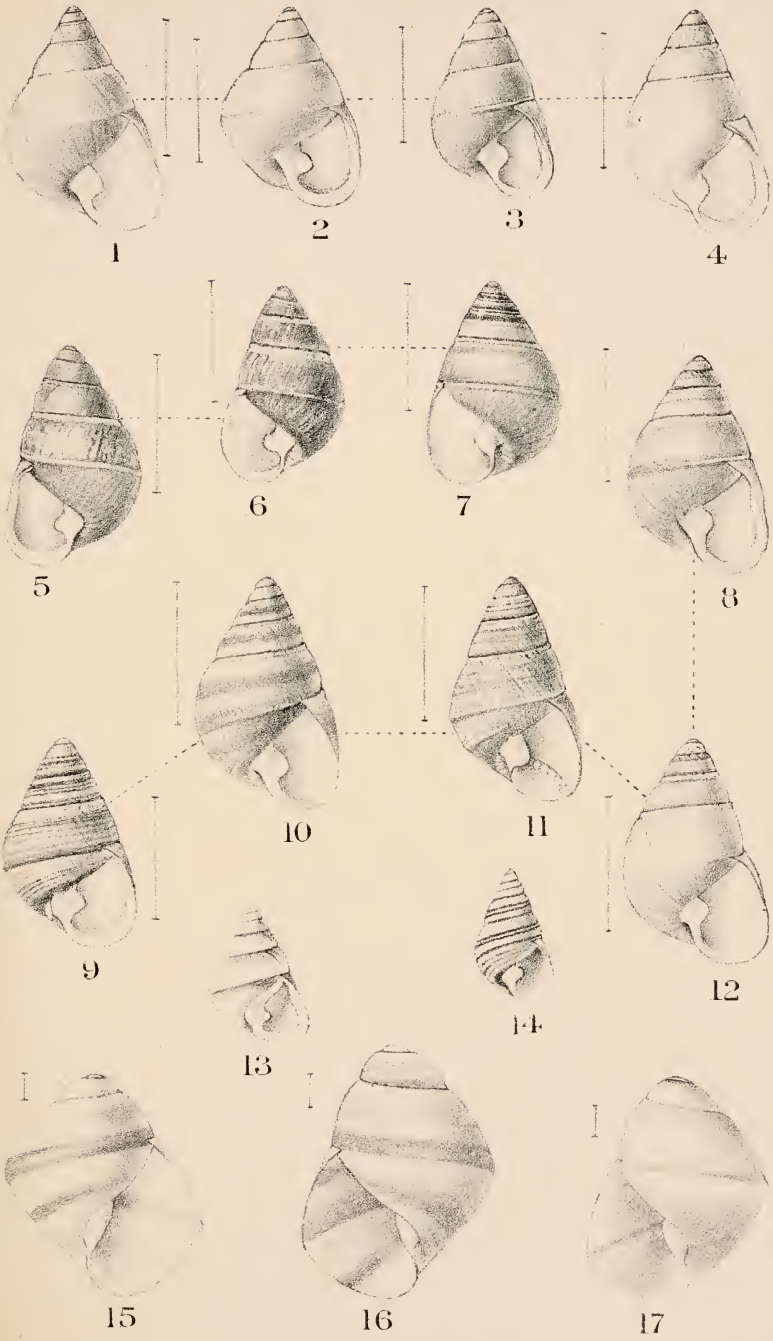
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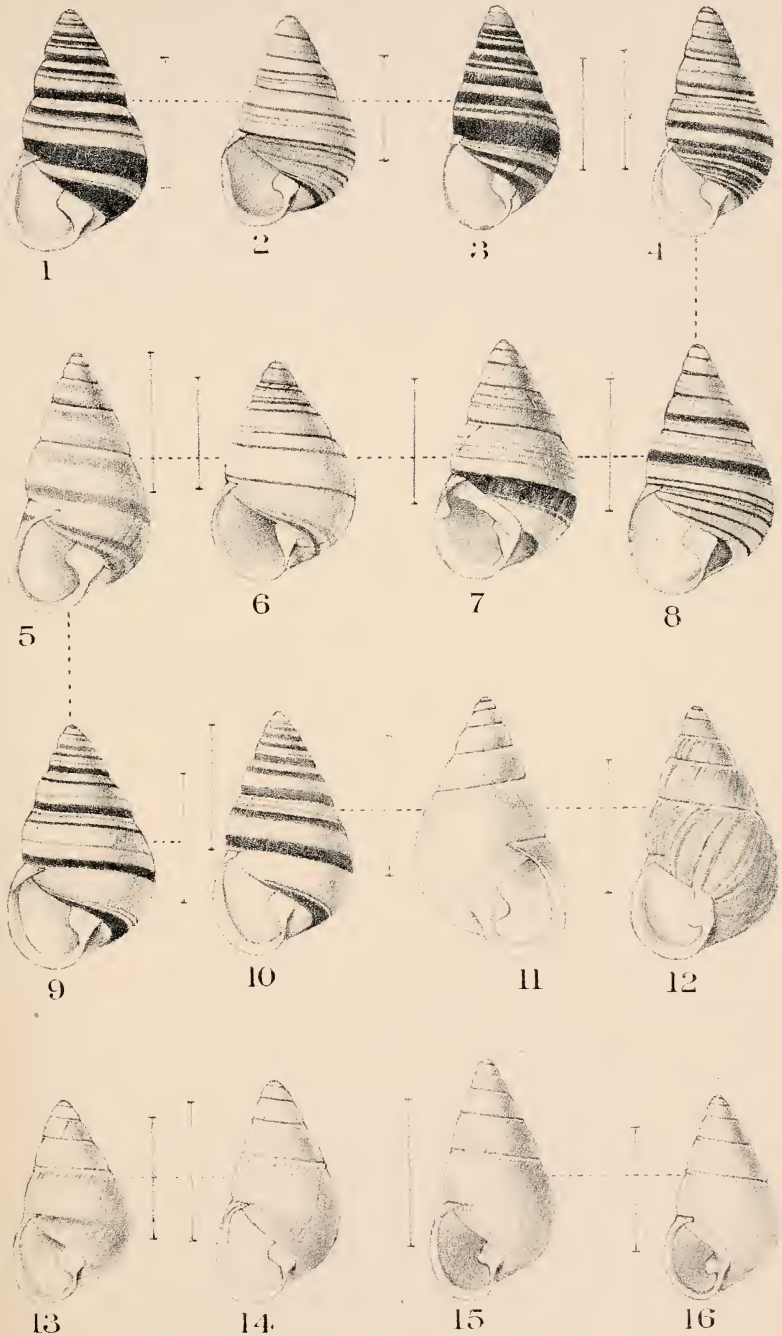
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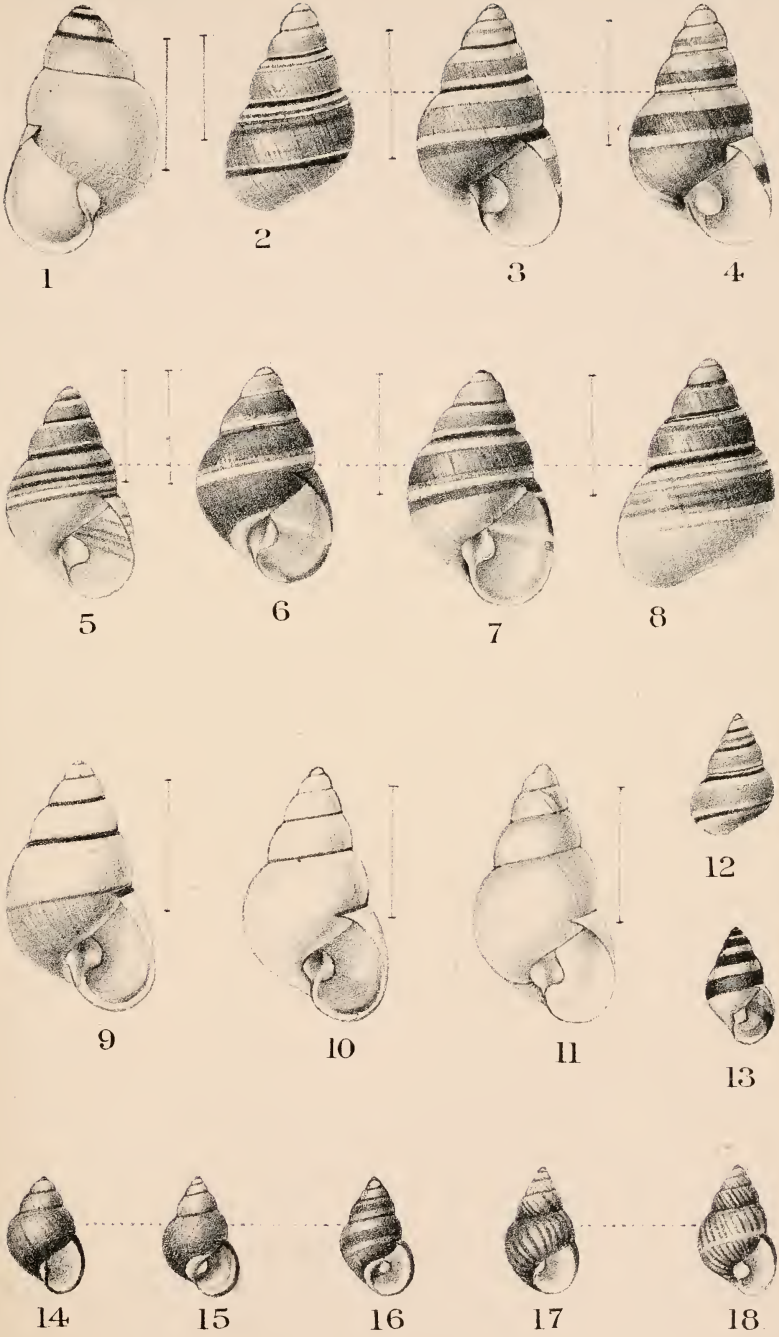
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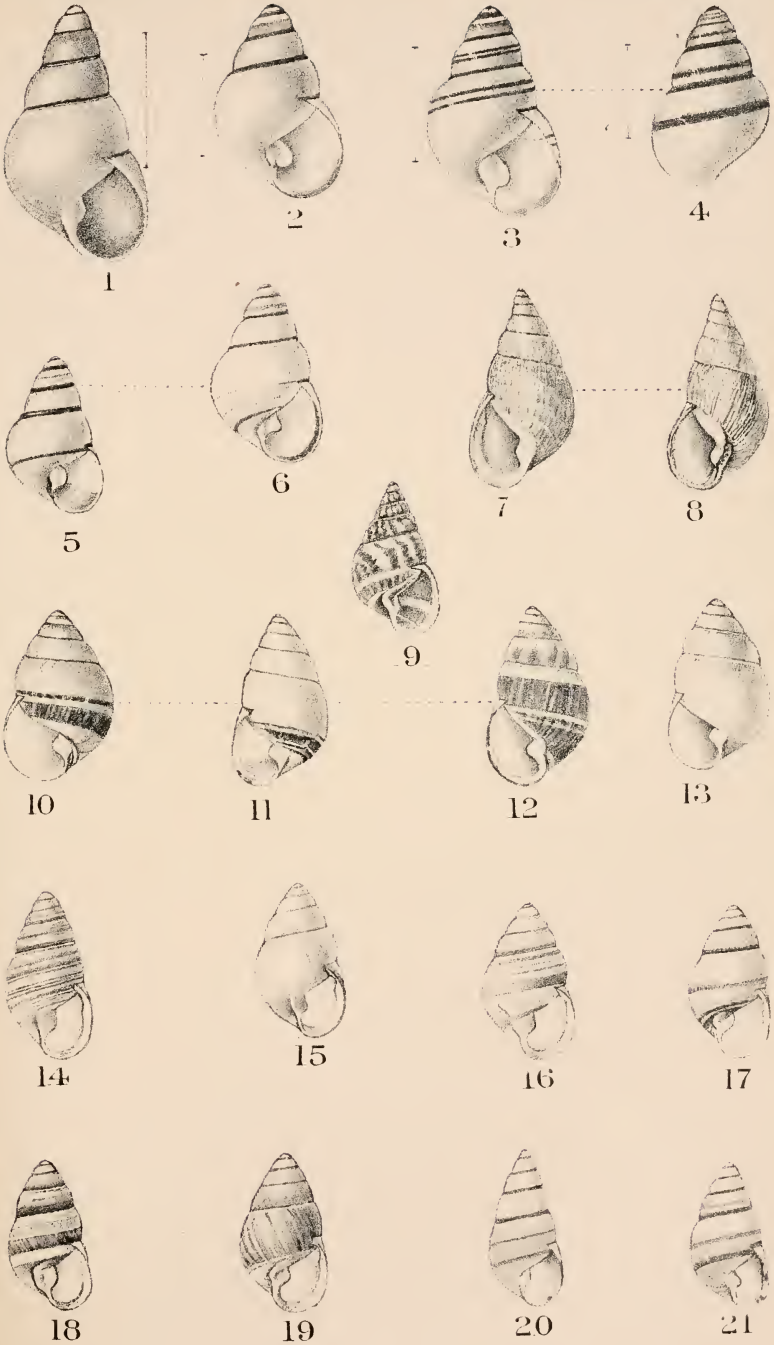
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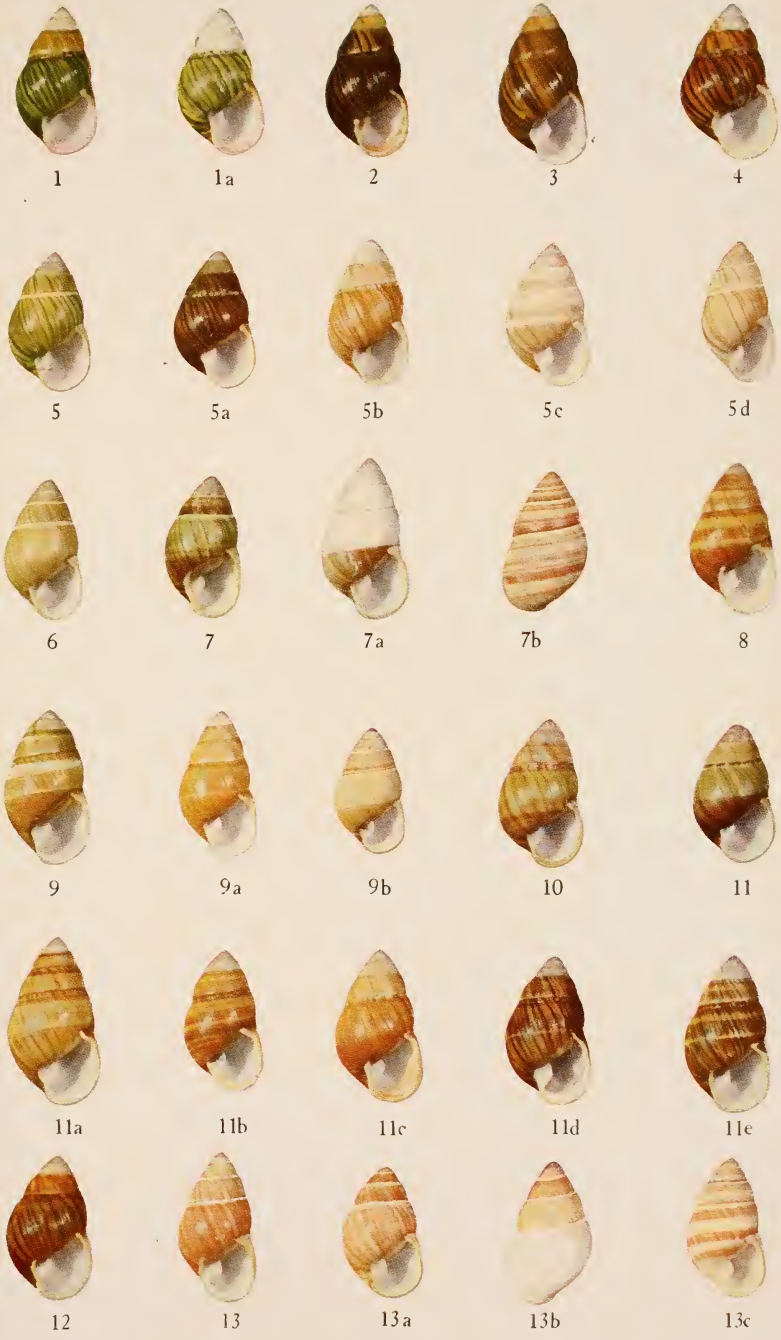
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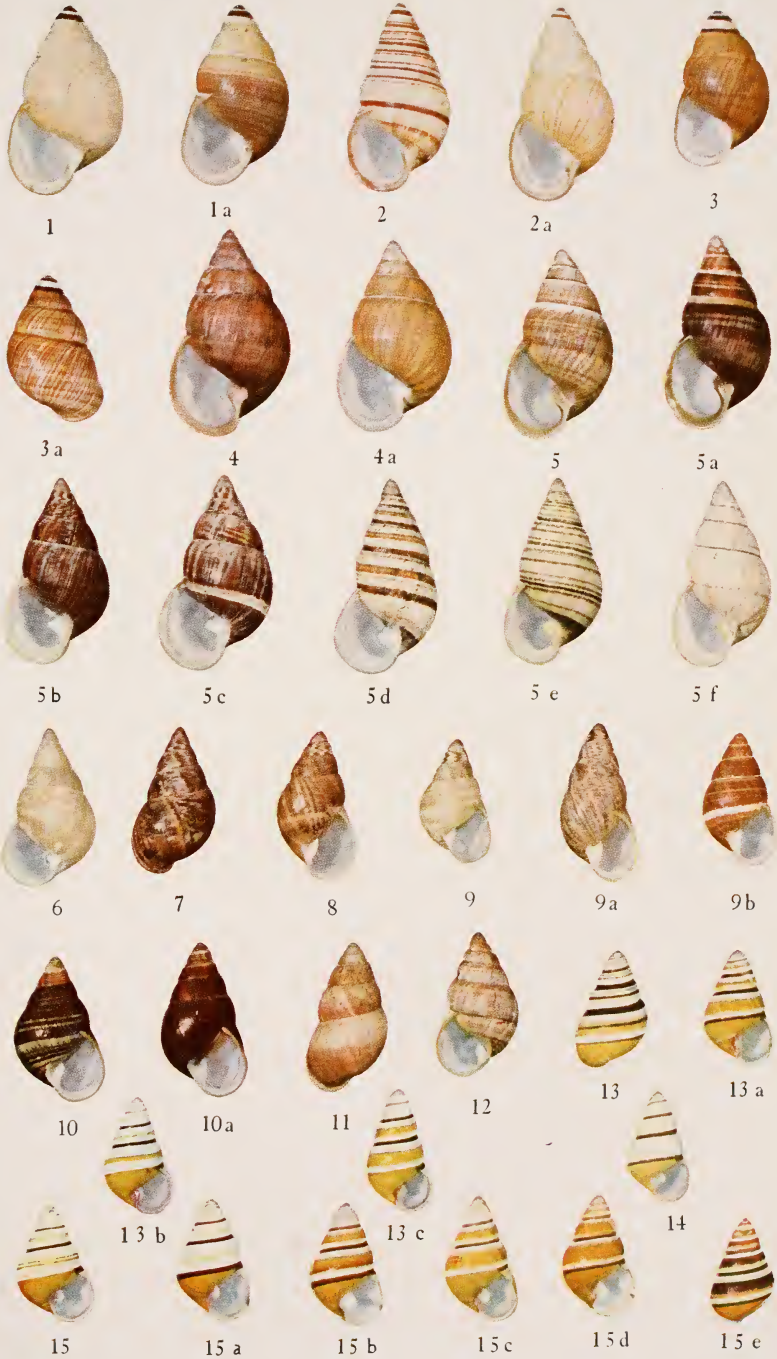
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surface slightly shining, the later whorls densely striate spirally, striæ waved, descending, embryonic whorls very densely and distinctly engraved. Embryonic shell of 3½ whorls, the first 2 whorls brown under a whitish layer; third whorl marked with oblique, angulated white stripes on a reddish-brown ground. Following (neanic) whorls mottled and streaked with white on a reddish-brown ground, which becomes paler on the last whorl, which is indistinctly streaked and mottled with creamy or brownish white, and girdled with a narrow dark band at the periphery. The whorls are strongly convex. Aperture slightly oblique, purplish-brown with light streaks within. Peristome a trifle expanding at the base, narrowly bordered within with white, but not thickened. Columella slightly convex, not plicate, the margin spreading in a triangle, white.

Length 17, diam. 10.5 mm.; fully 6 whorls.

Length 15.5, diam. 10.2 mm.; 5¾ whorls.

West Maui: Waiehu Gulch (D. Thaanum). Cotypes in coll. Bishop Museum and A. N. S. P. Also in Mr. Thaanum's collection at Hilo.

This very distinct species is evidently related to the East Mauian *P. grisea* Newc., from which it differs by the thinner shell of somewhat different contour, the more convex whorls, different pattern of the last embryonic whorl, larger umbilicus, dark peripheral band, etc. The aperture, lip and columella are more like *P. physa* than like *P. grisea*. The spire is less drawn out and not so narrow above. *P. aptycha* Pfr., which has not been found by recent collectors, is obviously distinct.

51. P. DUBIA (Newcomb). Pl. 26, figs. 7 to 12.

"Shell dextral, conically elongate, thin, finely decussately striated, light corneous with radiating zigzag lines and blotches of a light color. Whorls 6; suture simple. Aperture ovate; columella white and bulimoid except in strongly developed adults where it is callous and obtusely dentated. Umbilicus small but pervious. Lip thickened. Slightly reflected. Length 0.8, breadth 0.55 inch" (*Newc.*).

Oahu, among stones; Waianae, found on bushes (Newcomb). Waimano, eastern ravines southwest of forest fence; eastern ravines of Waiawa; east side of stream, Kawaihalona, in Waialua; also Makaha and Makua valleys, Waianae range (Irwin Spalding). In knot holes and crevices of loose bark of kukui trees. In Waimano on guavas.

Achatinella dubia Newc., Ann. Lyc. N. H. of N. Y., vi, p. 23 (May, 1853); P. Z. S., 1853, p. 152, pl. 24, f. 65, 1854.—*Achatinella platystyla* Gulick, Ann. Lyc. N. H. of N. Y., vi, p. 196, pl. 6, f. 25, 1856.—*Achatinella pexa* Gulick, Ann. Lyc. N. H. of N. Y., vi, p. 197, pl. 6, f. 26, December, 1856.—*Achatinella fucosa* Frick, Lyons, Hawaiian Almanac and Annual for 1892, p. 105, pl. 1, f. 15.—*A. morbida* Pfr., P. Z. S., 1859, p. 30.

P. dubia is a foreigner in Oahu; the strong spiral striation and the pattern of the embryonic whorls show it to be a real *Partulina*. Like *Laminella*, it seems to have wandered westward just before the connection with the Molokai-Maui mass was submerged. It is somewhat related to *P. grisea* and *P. thaanumiana* of Maui, *P. radiata* Gld. also has a close resemblance, but in this the *Partulina* pattern has been lost from the embryonic whorls, and the columellar fold is somewhat stronger. *P. radiata*, according to specimens in Mr. Emerson's collection, is from West Maui.

In his second account of this species Newcomb states that it may be either dextral or sinistral, and that old specimens exhibit "a flat, twisted tooth". His type figure is copied, pl. 24, fig. 9. This form has light girdles at periphery and base, with elsewhere a confused zigzag pattern of purplish-brown and white or cream. The narrow callus within the lip is white. Length 19.5, diam. 11, aperture 9.8 mm., whorls 6½. The smoothish and rather shining surface shows engraved spiral striæ throughout. The lower part of the outer lip and the basal margin are very slightly expanded. Ten of the specimens of this typical form before me are dextral, one sinistral. The last embryonic whorl has conspicuous zigzag white stripes on a dark ground. Pl. 26, fig. 7, is a specimen received from Newcomb. Other specimens, pl. 26, fig. 8, have

straight light yellow and brown streaks on the post-embryonic whorls. The smallest adult seen is 16 mm. long.

Probably all of Newcomb's shells, to which the above notes apply, were from the Waianae range, where it has been found in Makaha valley (on the southern side) by Mr. Spalding, and perhaps elsewhere by other collectors. Pl. 26, fig. 8, is a Waianae range shell.

In the main range *P. dubia* has an extended distribution, from Waimano to Waialua or Kawailoa, but only in a few places, so that it is regarded as a rather rare shell. Very fine series are in the collections of Messrs. Spalding, Emerson and Wilder. As a general rule, main range shells have a more thickened lip than those of Waianae, and the apex is often perceptibly blunter, whorls a trifle more convex; so far as I know, no sinistral shells have been found; but I am not satisfied that these small differences hold in all specimens.

In Waiawa (pl. 26, figs. 9, 9*a*, 9*b*, coll. by Spalding in the eastern ravines) the shell is streaked and mottled, with boldly zigzag-striped last embryonic whorl; or similar with a whitish peripheral band and several lines. Others are chestnut with pale streaks, a white peripheral band and several spiral light lines, the white zigzags of the embryo very much reduced (pl. 26, fig. 9 *b*), or white may predominate, the chestnut being reduced to bands narrower than the white, one specimen. In a few the later whorls are whitish with brown stains (pl. 26, fig. 9).

An extraordinary series was collected by Mr. Spalding in Waimano. Most of the colony is of the usual streaked and mottled form, but in a few the color is very deep, rich brown (between liver-brown or carob-brown and black, of Ridgway's Color Standards). This may be uniform or varied with light buff bands. The embryonic whorls are brown with light bands and lines, and on the last embryonic whorl there is a trace of the light stripes of the typical form. The figures, pl. 26, figs. 10, 10*a*, are from two specimens of Mr. Spalding's no. 2181. This color-form is one of the rarest Oahuan tree snails. A suspicion has been entertained that it might be a hybrid between *dubia* and a rare black form of *Ach. turgida*;

but having examined all of the specimens found, I think the evidence against that hypothesis.

Achatinella platystyla Gulick, pl. 26, fig. 11, and pl. 50, fig. 17, is a peculiar color-form of *dubia*, described from a single shell. The surface is a good deal pitted, but it was evidently a "live" shell, and an old one. The surface is entirely eroded to the middle of the fourth whorl. What cuticle remains on the next two whorls is pecan-brown with creamy streaks, and fading upwards. The last whorl is light buff in the upper third, shading downwards into pecan-brown, which is streaked with a lighter tint and has very indistinct spirals of the darker shade. The color is almost exactly that of some specimens of *Achatinella glabra*. The surface shows faint spiral striation, which becomes stronger upwards, as usual in *P. dubia*. The aperture, lip and perforation are exactly as in Main Range *dubia*. The lip has a faint yellow tint, deeper at the edge. Length 20, diam. 10.3, aperture 8.4 mm.; 6½ whorls.

The unique type of *platystyla* was collected by Mr. Gulick in Kawailoa. It is no. 25 of his type collection, Boston Society of Natural History. I have given two views of this specimen.

Achatinella pexa Gulick, pl. 26, fig. 12, is certainly a sinistral specimen of *A. dubia*. The unique type specimen, no. 26 of Gulick's type collection, coll. Boston Society of Natural History, is figured. The shell has the texture and thin substance of *dubia*. The ground-tint is between light buff and white. It appears in spirals and obliquely axial streaks, leaving rather wide interrupted streaks of vinaceous pink, here and there darker. There is a brown line at the periphery and a group of three around the umbilical region. The early whorls are eroded, but traces of alternate light and darker stripes can be made out on the last embryonic whorl. The glossy surface is engraved with rather distinct close spirals, as in *P. dubia*. The lip expands a little. Aperture, lip and perforation are as usual in *P. dubia;* the lip having a pale yellowish-brown edge and slight thickening. Length 19, diam. 10.7, aperture 9 mm.; 6½ whorls.

Another figure of the type of *pexa* is given, pl. 50, fig. 18, to show the form of the columella more distinctly than the figure on plate 26.

The pattern of color is practically the same as in some Waiawa *dubia*, though developed in delicate tints; and the specimen may have come from that neighborhood; yet it is sinistral with a thin lip, characters more in harmony with the Waianae range form. Gulick did not know the locality.

Achatinella morbida Pfeiffer. "Shell subperforate, sinistral, ovate-turrite, rather solid, striate and under a lens seen to be decussated with close spiral striæ; white, variously streaked and banded with brown; spire long, slender, the apex rather acute, suture simple; whorls 6½, very slightly convex, the last a little shorter than the spire, convex; columellar fold white, short, oblique; aperture oblique, inverted ear-shaped; peristome thickened, narrowly expanded, the columellar margin much dilated, broadly adnate. Length 19, diam. 9 mm. Sandwich Islands, Dr. Frick in Mus. Cuming." (*Pfr.*).

Achatinella morbida Pfr., Proc. Zool. Soc. London, 1859, p. 30; Monographia, vi, 167.

This species has not been figured. The description agrees well with sinistral *P. dubia*, such as are found in the Waianae Mountains; and a figure of the type-specimen which Mr. E. A. Smith kindly had made for me (pl. 41, fig. 4) confirms this determination. *A. morbida* is merely a somewhat unusual color-pattern of *P. dubia*.

Genus ACHATINELLA Swainson.

Achatinella Swains., Quarterly Journal of Science, Literature and Art (2 ser.), iii, June, 1828, p. 83; type *Monodonta seminigra* Lam. = *Achatinella apexfulva* Dixon.—Gulick, P. Z. S., 1873, p. 90, classification.—*Cochlogena*, quatrième groupe, Helicteres, Ferussac, Tableau Syst. de la Famille des Limaçons, p. 56, 1821.—*Helicteres* Fer., Beck, Index Molluscorum, p. 51, 1837.—Gray, P. Z. S., 1847, p. 178, type *Helix vulpina*.—Herrmannsen, Indicis Gen. Mal., i, p. 515, type *Helix vulpina* Fér.—*Helicter* Pease, P. Z. S., 1862, p. 3.—

Apex von Martens, Die Heliceen, 1860, p. 248, type *Achatinella lugubris* Chemn.

Shell imperforate or minutely perforate, oblong, ovate or globose-conic, smooth or longitudinally corrugated, with only minute and weak traces of spiral sculpture; color in spiral bands or streaks in the direction of growth-lines, never in forwardly-descending stripes; lip simple or thickened within, sometimes slightly expanding; columella bearing a strong callous fold.

Type *A. apexfulva* (Dixon). Distribution, the island of Oahu. Living on the leaves and limbs of trees and bushes.

Data on the soft anatomy, distribution, etc., of *Achatinella* may be found in the Introduction of this volume.

Achatinella was early divided into several subgenera or sections, but their contents as seen in the lists in *Die Heliceen, Nomenclator Heliceorum Viventium* and other works were rather heterogeneous. Gulick and Baldwin grouped the species more naturally, practically limiting the groups as in this work. Three sections or subgenera are recognized. There are a few species on the border between *Bulimella* and *Achatinellastrum,* but otherwise the sections are quite distinct, though they can scarcely be rigidly diagnosed.

Sections of Achatinella.

Bulimella Pfr. Outer lip thickened by a strong callous rib within; shape oblong-conic or ovate; summit obtuse, rounded or convexly-conic.

Achatinellastrum Pfr. Outer lip thin or a little thickened within, not expanded; early whorls not conspicuously flattened, the summit conic, not very obtuse.

Achatinella s. str. Outer lip well thickened within, scarcely or not expanded; shape globose-conic or ovate-conic, the summit conic, embryonic whorls flattened.

Section Bulimella Pfeiffer.

Bulimella Pfr., Malakozoologische Blätter, i, 1854, p. 119. —Martens, Die Heliceen, 1860, p. 244, type *A. rugosa* Newc.

Achatinellæ with the shell ovate-conic or somewhat pyra-

midal, the outlines of the spire more or less convex, at least near the rather obtuse summit; embryonic whorls not conspicuously flatter than those following; lip distinctly thickened by an internal callous rib (except in *A. abbreviata* and *A. lila*), the outer edge often slightly expanded.

Type: *A. byronii rugosa* Nc. Distribution: Entire Koolau or Main range of Oahu.

About forty-six names, most of them originally introduced as "species", have been applied to members of the *Bulimella* group up to this time. Mr. Baldwin, in his Catalogue of 1893, enumerated twenty-five species. Mr. E. R. Sykes (1900) admitted twenty species and three varieties. In the present monograph, thirteen species and eighteen subspecies are recognized; but this number includes two species and ten subspecies not before published. Most of the other names are synonyms, but a few may be retained for local forms thought to be below the grade of "subspecies". A more rigorously logical treatment might reduce the "good species" to nine, by the union of *viridans* and *tæniolata; byronii, decipiens* and *pulcherrima;* and *bulimoides* and *elegans;* but the price of such consistency would, I imagine, be the loss of clear conceptions.

Bulimella is a shell of the ravines as well as of the ridges, and before the extensive deforestation of the lower slopes, many fine species were to be found low in the valleys. This is especially true of the *bulimoides* group, which formerly occupied much territory now quite barren. The *fuscobasis* group is almost confined to high ridges and peaks.

The greatest development of *Bulimella* is in the northwestern half of the Koolau range. There are but four species and two or three subspecies in the whole southeastern third or more of the length of the island, leaving nine species and fifteen subspecies in the western five-eighths of the length. Moreover, the differentiation has been greater in the west, and doubtless new forms remain to be found there, whilst the eastern part of the range has been so fully explored that no new forms of *Bulimella* can be expected.

Bulimella contains the most roughly sculptured species of

the genus, some forms being irregularly corrugated in the direction of the lines of growth. Spiral sculpture is weak or obsolete in all the species.

There are three collateral groups or series of species in *Bulimella,* the first subdivided as a convenient geographic division.

Series of A. byronii: shell oblong-conic, often with streaks or bands of dark green, and often roughly striate or corrugated; mainly dextral. *A. byronii, pulcherrima, decipiens, lila.*

Series of A. viridans: a subdivision of the above series, for the exclusively dextral species of the eastern end of the range. *A. abbreviata, viridans,* and *tæniolata.*

Series of A. bulimoides: shell ovate, capacious, never marked with green; smooth, dextral or sinistral. *A. rosea, bulimoides, elegans.*

Series of A. fuscobasis: shell ovate-conic, never marked with green; smooth; mostly sinistral. *A. fuscobasis, sowerbyana, pupukanioe.*

On account of the wide variation in shape and color, it is not possible to rigidly diagnose these groups, which nevertheless express the natural affinities of the species.

Key to species and most subspecies of Bulimella.

I. Forms of the southeastern third of the main range (east of Moanalua).

a. Lip acute, but slightly or not thickened within; shell dextral, very smooth, richly colored. *A. abbreviata,* no. 1.

*a*¹. Lip strengthened by a callous rib.

b. Shell dextral.

c. Streaked with green or chestnut on a lighter or yellow ground. *A. viridans,* no. 2.

*c*¹. Banded or streaked with chestnut on a white ground, or white. *A. tæniolata,* no. 3.

*b*¹. Shell sinistral.

c. Shell white with few brown bands or none, about 16 x 10 mm. *A. fuscobasis,* no. 11.

*c*¹. Similar but larger and more capacious. *A. f. lyonsiana,* no. 11*a*.

c^2. Shell richly colored, banded. Lanihuli.
A. f. wilderi, no. 11*b*.

II. Forms of the northwestern two-thirds of the main range.

a. Lip acute, but slightly or not thickened within; shell sinistral, very smooth, richly colored. *A. lila,* no. 5.

a^1. Lip distinctly thickened within.

b. Shell oblong-conic.

c. Surface corrugated or somewhat roughened by growth-wrinkles.

d. Interior drainage; shell sinistral, later whorls corrugated, intensely black or banded with dark green. *A. b. nigricans,* no. 4*b*.

d^1. Interior drainage; shell dextral.

e. Roughly striate, streaked with green, chestnut or black, usually with sutural chestnut band or others; lip edged with brown. *A. byronii,* no. 4.

e^1. More corrugated, occasionally black; surface with a gummy gloss; whole lip usually brownish; length 16-19 mm.
A. b. rugosa, no. 4*a*.

e^2. Larger, broader, green-streaked; lip white or narrowly dark-edged; length 19-21 mm. Var. *capax.*

e^3. Nearly smooth, whitish to greenish-yellow, plain or banded, lip white or pale lilac; length 15-18 mm. Var. *waimanoensis.*

d^2. Northern (Koolauloa) slope; shell sinistral or dextral, the lip mainly white.
A. decipiens, no. 7.

c^1. Surface smooth; shell dextral.

d. Northern slope; lip white. Various varieties of *A. decipiens,* no. 7, 7*a*.

d^1. Interior slope.

e. Lip bordered with blackish brown.
A. pulcherrima, no. 6.

e^1. Lip white throughout. *A. p. nympha,* no. 6*a*.

b^1. Shell ovate, smooth.

c. Larger, capacious species, diam. 10 mm. or more.

d. Shell sinistral, highly polished, usually white or with rose bands, lip bright rose; rarely greenish or dark, with dark brown lip.
A. rosea, no. 8.

d^1. Dextral or sinistral, variously banded with chestnut or suffused, lip pale or brown.
A. bulimoides, no. 9.

d^2. Dextral or sinistral, conspicuously streaked with brownish, sometimes with white bands also, lip brown. *A. elegans,* no. 10.

d^3. Chiefly sinistral, blue-gray or purplish, sometimes banded. *A. e. wheatleyana,* no. 10*a*.

c^1. Smaller species, usually less than 10 mm. diam.

d. Shell sinistral.

e. Wax-yellow with a brown sutural band, sometimes one or two other bands, columella pink. *A. sowerbyana,* no. 13.

e^1. Wax-yellow below, white above periphery, with a subperipheral brown band; columella pink. *A. s. thurstoni,* no. 13*a*.

e^2. White, usually with broad chestnut bands; columellar fold white or brownish.
A. s. laiensis, no. 13*b*.

d^1. Shell dextral.

e. Wax-yellow with white sutural band, columella pink. *A. s. roseoplica,* no. 13*d*.

e^1. Ground white or pale, uniform, or banded or streaked with chestnut.
A. pupukanioe, no. 12. *A. s. dextroversa,* no. 13*c*.

Series of A. viridans.

(Species of the east end of the Main Range.)

These forms, which are invariably dextral, inhabit the valleys from Nuuanu to the southeastern end of the range. Between Nuuanu and Waimanalu there are about half a dozen great ridges and valleys where no *Bulimella* is known except *A. fuscobasis wilderi* on some high points of the main axis.

The *viridans* group is somewhat intermediate between the *byronii* and the *bulimoides* series, but most nearly related to the former by the frequent development of bright green color, which none of the *bulimoides* series has. Besides the following forms, one unrelated sinistral species occurs on the southeastern ridges, *A. fuscobasis,* no. 11.

1. A. ABBREVIATA Reeve. Pl. 31, figs. 1 to 5*a*.

"Shell ovate, somewhat ventricose, dextral; whorls convex, margined round the upper part; spire rather short, obtuse at the apex; columella callous, twisted. Olive-yellow, with a black-brown line at the sutures, lower part of the last whorl very dark green, apex black." (*Reeve.*)

Oahu: Eastern ridge of Nuuanu to Niu. Palolo (Gulick and others; type loc.); around edge of the crater, and Palolo-Waialae ridge (Spalding); northwestern ravine, next to the Palolo-Manoa ridge (Pilsbry & Cooke). Konahuanui (Baldwin); eastern Nuuanu, perhaps washed down from Konahuanui (Spalding). Waialae, Niu, and over the ridge in Kailua (Gulick).

Achatinella abbreviata REEVE, Conch. Icon., vi, pl. 3, fig. 19, April, 1850.—PFR., Monogr., iii, 460; iv, 532; vi, 172.—BALDWIN, Catalogue, p. 5.—SYKES, Fauna Hawaiiensis, p. 305.—THWING, Orig. Descr. Achat., p. 81, pl. 1, f. 22.—GULICK, Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 25.—*Achatinella bacca* Reeve, Conch. Icon., vi, pl. 6, f. 45, May, 1850.—GULICK, Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 22.—*Achatinella nivosa* NEWC., P. Z. S., 1853, p. 132, pl. 22, f. 6 (Niu).—*Achatinella clementina* PFR., P. Z. S., 1855, p. 205; Monogr., iv, 534.

A. abbreviata differs from the *viridans* forms by its broad contour, thin outer lip, smoother surface and different pattern, yet is related to them by color and the faint traces of corrugation noticeable in some specimens. It is a very distinct species.

A. abbreviata is a common species around the crater of Palolo valley, and on its bounding ridges near the heads of the upper ravines. It lives by preference in the axils of ieie. Hot

water, or too prolonged soaking, changes the vivid green color to a dirty olive-brown. The western extreme of its range is (or was) in eastern Nuuanu, near the southeastern edge of the new dam, where Mr. Spalding found five immature specimens of the profusely-banded form (no. 1817 of his collection), possibly washed down from Konahuanui.

Pl. 31, figs. 1, 1*a*, 5, 5*a*, Palolo, are from Gulick shells. The others, figs. 2 to 4*d*, are from material collected recently. A lot from the northwestern ravine of Palolo varies from many-banded to black (pl. 31, figs. 4, 4*a*-4*d*). There was also one shell all green except the brown summit. Figs. 3*a*, 4*d*, 5 and 5*a* are rare color-forms.

The shell is obesely-ovate, very glossy, showing faint spiral striation on the lower, clear but very fine incised lines on the early whorls. The lip is acute, not thickened within or but slightly so. All I have seen are dextral.

1. The typical color-pattern as figured by Reeve is yellow above the periphery, green below it, the colors separated by a peripheral chocolate band. The suture is bordered above and below by chocolate bands. Near the summit the yellow ground gives place to reddish-brown, becoming dusky or purplish-brown at the apex (pl. 31, fig. 2). This pattern occurs in Palolo valley together with the following, *the intergradation being complete* throughout the series.

2. Similar to no. 1, but having additional chocolate lines and bands (pl. 31, fig. 2*a*, Palolo; figs. 3, 3*a*, Palolo-Waialae ridge), which sometimes almost cover the yellow and green ground.

3. Same as no. 2, but without green (pl. 31, figs. 4, 4*a*), or the bands may be confluent, leaving yellow bands at periphery, suture or both (fig. 4*b*).

4. Last whorl black or nearly so, bandless, the color becoming lighter upward, dark again at the summit (pl. 31, figs. 4*c*, 4*d*). This is the form called *A. bacca* by Reeve. *A. abbreviata* and *A. bacca* are therefore merely selected patterns in a continuous series of variations occurring in the same colony. Figs. 4 to 4*d* are from a northwestern ravine of Palolo, next to the Manoa ridge, coll. by Pilsbry.

5. Shell yellow above (varying to olivaceous or brownish-yellow), green, dull olive or even chestnut below the periphery, usually bandless, sometimes having one or several reddish-brown bands. The columellar fold is not so strong as in the preceding. (Pl. 31, figs. 1, 1*a*, Palolo.) So far as I know, this form does not occur in colonies of the chocolate-banded forms. There is a large lot from Palolo in the Gulick collection, 92572 A. N. S.

Waialae. Several lots collected by Gulick and others have the patterns of figs. 2*a*, 3, 3*a*, 4*b*, *c*, *d*, not distinguishable from Palolo shells. Another lot agrees with fig. 1. Pl. 31, figs. 3, 3*a* are from the Palolo-Waialae ridge, collected by Mr. Kuhns.

Wailupe. Occurrence doubtful.

Niu. Many-banded shells, pattern of fig. 3, collected by Gulick.

The locality "head of Kawailoa Gulch, Perkins," given by Mr. Sykes, must be an error in labeling or determination.

A. nivosa Newc. is universally admitted to be a scraped *abbreviata*. The original figure is reproduced, pl. 29, fig. 6.

A. clementina Pfr. has not been figured. It has been placed in the synonymy of *abbreviata* by Pfeiffer himself and by subsequent authors. The description, which is not very good for *abbreviata*, here follows: "*A. clementina*. Shell imperforate, dextral, ovate-conic, solid, nearly smooth, glossy; greenish-brown, banded below the suture with buff. Spire regularly conic, obtuse, suture chestnut, impressed-marginate, crenulated. Whorls 6, a little swollen above, the last about equal to two-fifths the total length. Aperture oblique, truncate ear-shaped, white within; columellar fold above, moderate, white or flesh-colored. Peristome unexpanded, the margins joined by a callous, right margin somewhat straightened, thickened-labiate within; columellar margin dilated, adnate. Length 19, diam. 10, aperture 9½ mm. long, 4½ wide. Oahu, Frick in Cuming coll." (*Pfr.*)

2. A. VIRIDANS Mighels. Pl. 25, figs. 1 to 4; pl. 31, figs. 6, 6*a*.

"Shell dextral, elongate-conic, green with light streaks in-

termixed, imperforate. Whorls 5, convex, with a revolving, slightly impressed line below the suture. Aperture subovate, stained with a pink color just within the margin; lip slightly thickened. Length three-fourths, diam. seven-fifteenths inch" (*Mighels*).

Oahu (Mighels). Nuuanu to Palolo, various color-forms as far east as Niu.

Achatinella viridans Mighels, Proc. Boston Soc. Nat. Hist., ii, p. 20, January, 1845.—Pfr., Monographia Hel. Viv., ii, 240; iv, 519; vi, 164; Conchyl. Cabinet, *Bul.*, p. 286, pl. 67, f. 16, 17.—Newcomb, P. Z. S., 1854, p. 310 (animal).—*Achatinella radiata* Pfr., P. Z. S., 1845, p. 89 (January, 1846).—Reeve, Conch. Icon., pl. 5, f. 35.

Achatinella subvirens Newc., P. Z. S., 1853, p. 136, pl. 22, f. 18, 1854.—*Achatinella rutila* Newc., P. Z. S., 1853, p. 138, pl. 22, f. 21, 1854; p. 310 (animal); Ann. Lyc. N. H. of N. Y., vi, 326 (animal).—*Achatinella macrostoma* Pfr., P. Z. S., 1855, p. 2, pl. 30, f. 6; Monogr., iv, 520 (Sandwich Is., Frick in Cuming coll.).

The type of *A. viridans* was lost by fire, but the description applies well to the form found in Nuuanu, Manoa and Palolo valleys, and which has always been considered *viridans* by Hawaiian collectors. C. B. Adams, who had seen Mighels' specimen in his collection, stated that it was identical with *A. radiata* Pfr. as figured by Reeve. The traditional identification of *viridans* is therefore confirmed, that figure being the same as our pl. 25, fig. 1. The shell is glossy, noticeably, though weakly, corrugated. The first three whorls are whitish, or white when the thin cuticle is lost; next whorl or two yellow or olivaceous, more or less streaked; last 1½ or 2 whorls copiously streaked throughout with dark and light green of several shades. The sutural border is distinctly marked by an impressed line. The aperture is white within, the lip a trifle expanded, thickened within, and either white or flesh-pink. In a large number of specimens seen, not one is sinistral. The size and form vary, but shells 20 mm. long, 11 wide are about normal. A wide shell from Nuuanu measures, length 20.2, diam. 13 mm.

In Nuuanu valley the shells vary from typical green color to a form in which the dark green is replaced by blackish-chestnut, light green by yellow (pl. 25, fig. 4). A specimen of the rather widely-spread form of Upper Nuuanu, pale yellow with light yellowish olive streaks, is figured on pl. 31, fig. 6*a*, coll. by Mr. Richard A. Cooke. A small, thin-shelled form was found only on a few isolated bushes at the head of the valley just west of the pali. It is chestnut-brown with lighter streaks and pale lines below suture and periphery; lip-callus narrow; length 15.8, diam. 8 mm. Pl. 31, fig. 6, coll. by R. A. Cooke.

In Manoa Gulick collected the typical green form (pl. 25, figs. 1, 1*a*); others having black, others olive (pl. 25, fig. 3) or chestnut streaks on a yellow ground. There is now no forest low in Manoa valley.

Palolo has the same range of forms shown in figs. 1 to 3. A black-streaked shell is figured (pl. 25, fig. 2, collected by Gulick). Really typical *viridans* does not go eastward of Palolo, so far as I know. It is a rather homogeneous race, having the same pattern but in varying shades and colors. Probably green, olive, chestnut and black are varying stages of oxidation of the same pigment; or perhaps the dull ground of some specimens may be due to cleaning with hot water. In Palolo the forms *rutila* and *subvirens* also occur, whether associated with the typical *viridans* pattern I do not know.

Doctor Newcomb has given the following description of the soft parts. *A. viridans:* "Animal light gray; tentacles and tentacular sheath dark slate; mantle thick, yellowish-brown. Tentacles strongly clubbed, short and robust, when extended, longer than the shell."

A. rutila: "Animal small in proportion to the shell, of a uniform yellowish-white, retractile part of upper tentacles of a light-brown; tentacles filiform and slightly clubbed; foot very broad, long as the shell; mantle same color as the animal."

Eastward of Palolo the typical *viridans* pattern disappears, and the color-forms *rutila* and *subvirens* replace it. These are often hybridized with more or less blending, so that the ap-

pearance of a colony suggests *rutila* × *subvirens* or *rutila* × *tæniolata*. It might be well to recognize *subvirens* as an eastern subspecies of *viridans, rutila* and *macrostoma* to be synonyms of it.

Color form *rutila* Newcomb. Pl. 25, figs. 10, 11, 11*a-e*, 12.

"Shell ovately-conic; whorls 6, rounded, the last margined above; suture well marked; aperture subquadrate; lip expanded, subreflected, strongly thickened within; columella short, terminating in a strong, twisted plait. Color a light straw, olive or brown; lip white or somewhat roseate. Length 17, diam. nine-twentieths inch." (*Newc.*)

Niu (Newcomb, type loc., pl. 25, figs. 10, 11 to 11*e*. The color-form figured by Newcomb as typical is streaked with light green on a yellow-green ground, with several spiral brown bands below the periphery (pl. 29, fig. 21, reproduction of Newcomb's type figure; pl. 25, fig. 10, specimen from Newcomb). In other shells from Niu, collected by Gulick, figs. 11 to 11*e*, the spiral bands may be more numerous or they may be wanting. The streaks are sometimes chestnut or umber, and either distinct or blended. *The sutural border is almost invariably tessellated with brown,* thus differing from var. *subvirens,* in which it is white, or at least not more heavily marked than the rest of the shell. Wailupe shells are similar (pl. 25, fig. 12).

In Waialae valley the color is usually light, and specimens having bands like *rutila* with the white suture of *subvirens* were found by Gulick and kept by him in the same lot with others having the tessellated suture of *rutila*. See pl. 25, figs. 5 to 5*d*. There is no definite break between the two forms, merely a matter of one or another color-mutation prevailing in the colony. Even as far west as Palolo there are some shells with more or less tessellated sutural border.

A. macrostoma Pfr. seems to me to be a form of *rutila,* as Newcomb held, specimens of similar pattern to Pfeiffer's figured type occurring in Waialae Nui (pl. 25, fig. 8, Cooke coll.). The original figure is reproduced, pl. 30, fig. 6. Mr. Sykes has thought it a synonym of *tæniolata,* and it must

be admitted that some of the yellow-ground specimens from colonies presumably *tæniolata* × *subvirens* have a great resemblance to Pfeiffer's figure. The original description follows. "*A. macrostoma* Pfr. Shell dextral, imperforate, conic-ovate, rather solid, very lightly striated, glossy; fulvous, variegated with some pale and brown bands. Spire conic, rather obtuse; suture submarginate; whorls 5½, moderately convex, the last equal to the spire, swollen above, contracted in the middle, rounded at base. Aperture slightly oblique, ample, reversed auriform, white within; peristome white, labiate within, the right margin expanded, strongly curved above; columellar margin dilated, adnate. Length 21½, diam. 11 mm.; aperture 12 mm. long, 5 wide inside. Inhabits the Sandwich Islands, Frick; Mus. Cuming (*Pfr.*).

Color-form *subvirens* Newc. Pl. 25, figs. 5 to 7*b*, 9 to 9*b*.

"Shell conically ovate. Whorls 6, rounded and margined above; suture distinct and lined with white. Aperture ovate, expanded below; lip thickened; columella short, flat and obliquely truncated; color of epidermis light green, interspersed with a lighter shade arranged longitudinally; columella, lip and aperture white. Length 15, diam. seven-twentieths of an inch. Niu, Oahu.

"Var. *a*. Pure white.

"Var. *b*. Brown or chestnut replacing the green color.

"Through var. *a* this species approaches a variety of *A. rutila*, and through var. *b*, *A. decipiens*. It is readily distinguished from the first by its smaller size, greater solidity, stronger striæ and more elongate form; from the latter by its less acuminate form, white suture, less solidity, and their widely separated localities" (*Newcomb*).

Newcomb's figure of the type from Niu is reproduced, pl. 29, fig. 18. The lip is white or yellowish, the green color is paler than in *viridans*, surface less wrinkled, and typically *the sutural margin is white*, though very often the dark lines extend over it. It differs from *viridans* in the average, but one could not pronounce on every specimen, and if Gulick's lots are reliable, it occurs in the same colonies with *rutila*.

The same variety occurs in Wailupe and Waialae valleys. A series is figured, pl. 25, figs. 5 to 5*d*, Waialae; also pl. 25, fig. 6, a clear green shell occurring with the brown-streaked form, Wailupe. Some shells from Waialae have spiral bands as in var. *rutila* (pl. 25, figs. 7 to 7*b*).

Gulick found a few *subvirens* also in Palolo, the white, green-streaked and brown-streaked forms. Also specimens connecting with form *rutila,* the sutural border yellow in some, white in other examples. Color yellow with indistinct olive lines, bandless or with white or chestnut bands (pl. 25, 25, figs. 9, 9*a*, 9*b*, Palolo).

3. A. TÆNIOLATA Pfeiffer. Pl. 24, figs. 14 to 19; pl. 25, figs. 13 to 13*c*.

"Shell ovate-oblong, solid, striatulate, glossy; white ornamented with varying brown bands, more obsolete above. Spire conic, rather acute. Whorls 6, slightly convex; the last about four-ninths the length. Columella white, strongly tooth-folded above. Aperture irregularly semioval, white within, glossy; peristome very narrowly thickened outside, strongly lipped within, the columellar margin dilated, reflexed, appressed. Length 20, diam. in the middle 11 mm.; aperture 10 x 4½ mm. Sandwich Is., Mus. Cuming." (*Pfr.*)

Oahu: Palolo to Keawaawa, and northward across the range in Maunawili.

Achatinella tæniolata PFR., P. Z. S., 1846, p. 38; Monographia, ii, 239; iv, 519; vi, 164.—REEVE, Conch. Icon., pl. 1, f. 7.—NEWCOMB, Ann. Lyc. N. H. of N. Y., vi, p. 320.—SYKES, Fauna Hawaiiensis, p. 310.—*Achatinella rubiginosa* NEWCOMB, P. Z. S., 1853, p. 154, pl. 24, f. 69 (Palolo).

A. tæniolata typically has a *white ground,* variously banded or streaked with rufous or ochraceous-orange, or without markings. The contour is usually somewhat more capacious and the surface smoother than in the forms *subvirens* and *rutila* of *A. viridans*; but both contours and sculpture intergrade in some shells. The coloration is characteristic in typical examples, but here again there are colonies from Palolo, Waialae, Keawaawa and elsewhere, which could be placed,

with almost equal propriety in *tæniolata, viridans rutila* or *viridans subvirens,* or assorted into these several strains. The fact seems to be that several forms, well differentiated in pure colonies, have interbred in other places, forming hybrid colonies. Strictly speaking, *tæniolata* is a subspecies of *A. viridans,* because there is complete intergradation between them; but as the race is *usually* quite recognizable, it is here admitted as a species. In dealing with *Achatinella* it is impossible to be logical and at the same time preserve a practically useful classification.

The color in Palolo shells varies from white to few-banded or many-banded with light reddish-brown, apex and sutural border white, or rarely the apex is purplish-brown, perhaps stained from within (pl. 24, figs. 15, 16, Palolo, Gulick coll.).

Length 20, diam. 10.2 to 11.2 mm.

Length 18, diam. 11.5 mm. (exceptionally obese).

Length 21, diam. 10.8 mm.

Length 21, diam. 11.8 mm.

As these shells agree well with Pfeiffer's description and Reeve's figure, Palolo may be taken as type locality.

In some colonies the color-form *rubiginosa* Newc. (pl. 24, fig. 19, Palolo, and pl. 25, figs. 13, 13*a*, Wailupe, all from Gulick coll.) is prevalent, together with banded shells. In this form the shell is suffused and streaked with rufous, a band or line below the suture and a columellar patch usually white. Typical *tæniolata* might be described as *rubiginosa* in which white bands traverse the shell spirally, cutting the dark color into bands. It has thus a more advanced pattern than that of *rubiginosa,* and the white shells are still further evolved, though the pattern is degenerate.

According to Newcomb, *rubiginosa* has a light flesh-colored, and *tæniolata* a brown or dark slate-colored animal and mantle. In his later paper he admits the specific identity of *rubiginosa* and *tæniolata.*

In Waialae (pl. 24, fig. 14) and Wailupe some large lots taken by Gulick are white or with but few spiral lines or none, while in others the profusely banded and the *rubiginosa* type of coloring prevails. Pl. 25, figs. 13 to 13*c* are Wailupe shells

collected by Gulick. A recently collected Waialae lot from Thaanum consists of (*a*) white shells with brown spire, (*b*) white shells with numerous brown bands, as in Palolo *tæniolata*, and (*c*) greenish-yellow shells with chestnut-olive streaks, sometimes cut by white bands. There are various blends between *a* and *c* patterns. This colony is probably a *subvirens* × *tæniolata* hybrid.

A small lot from Niu (Gulick) consists of well-colored banded shells (*tæniolata*), or streaked (*rubiginosa*), with white ground.

From Kuliouou (Thaanum) the specimens have the pattern of Keawaawa form (*b*), see below.

In a set of 9 from Keawaawa, coll. by Gulick, some have a few faint bands, others being white, peristome and parietal wall yellowish. The shape varies, as in Palolo shells: length 19, diam. 10 mm., to length 17, diam. 10½ mm. A lot from the Thaanum collection, recently collected, there are (*a*) shells variously banded with chestnut on a *yellow* ground; (*b*) the same with many oblique streaks or lines added, and (*c*) others of *rubiginosa* pattern, the streaks blended. The yellow ground shows probable hybridism with *rutila* or *subvirens*.

On the northern side of the main range Gulick obtained a few specimens in Kailua—rather an indefinite locality. They have streaked *rubiginosa* coloring, with paler spiral bands. One has a greenish tone. They are transitional between *rubiginosa*, *tæniolata* and *subvirens*. Size rather small, length 17 mm. It occurs also in Maunawili, on the northeastern slope of Mt. Olympus, a place exploited by Messrs. Kuhns and Wilder. Here the shells are white with dark or light-brown upper whorls, paler (sometimes white) embryonic whorls, the last whorl either banded or with *rubiginosa* pattern cut by one or more white bands. Pl. 24, figs. 17, 18.

(Species of the northwestern two-thirds of the Main Range.)

Series of A. byronii.

What forms of the *byronii* group may occur upon the crest of the main axis of the range between the known areas of *byronii* and *decipiens* are not known to me. For this reason,

and because there are differences in the patterns and colors, I am recognizing the forms from the northward side, collectively, as a species (*A. decipiens*) distinct from those on the south side of the range. The *decipiens* forms all appear to be more closely related to one another than any of them are to forms from the other side of the range, They seem to form a parallel series to the latter. In both series there are smooth forms in the west, corrugation becoming progressively more emphatic eastward. In both series the western forms are invariably dextral, and sinistral forms occur in the east. This correspondence would suggest communication across the range, but the coloration is against that explanation of the parallelism. From northwest to southeast the forms are arranged thus: smooth, dextral forms above (westward), rough, sinistral forms below (eastward).

	kaliuwaaensis
pulcherrima	
byronii	decipiens
rugosa	corrugata, torrida
nigricans	

Dr. C. Montague Cooke considers *decipiens* with its varieties to be a subspecies of *byronii*. In retaining *A. pulcherrima* as a species, I am following Dr. Cooke's counsel, although I have some doubt whether it should be given higher rank than a subspecies of *A. byronii*. It is a case where there are numerous local forms the variations of which overlap more or less, and whether they are ranked as forms of one species, or are more or less arbitrarily assorted into several, is a matter of convenience in referring to the forms. The series shows such diversity of differentiation that it would be rather meaningless to lump all of the races under the one name, *A. byronii*.

Practically all of the Newcomb and Gulick shells were taken at low levels, chiefly in places where there are now no forests. The modern collector in this part of Oahu rarely finds tree-snails below the forest fence, which follows the 1,000 ft. contour from Waimea to Moanalua.

4. A. BYRONII (Wood). Pl. 27, figs. 1 to 1*e*, 3.

The shell is dextral, imperforate; pyramidal-conic with ob-

tuse summit, solid, glossy. Color variable, but typically green and light greenish-yellow in oblique streaks on the last two whorls, having a faint green peripheral band and a dark chestnut band bordering the suture below; next earlier whorl yellow with a chestnut band, nearly three embryonic whorls pinkish gray; aperture white, the lip bordered with dark brown. Sculpture of faint spiral striæ on the embryonic whorls, later whorls *irregularly wrinkled* in the direction of growth-lines, under the lens showing very faint traces of a fine oblique malleation. Whorls 6½, somewhat convex, the last often very obtusely angular at the periphery. Aperture strongly oblique, the lip thickened within by a strong rib near the margin. Columellar fold moderate, white or tinted.

Length 20, diam. 11 mm. (typical size).

Length 18, diam. 11 mm.

Length 17, diam. 9½ mm.

Oahu: Kalaikoa, Ahonui (Gulick).

Helix byronii Wood, Supplement to the Index Testaceologicus, or a Catalogue of Shells, British and Foreign, 1828, p. 22, no. 30, pl. 7, f. 30.—*Achatinella byronii* Wood, Newcomb, Ann. Lyc. N. H. of N. Y., vi, p. 318.—Pfr., Monogr., vi, 165.—Sykes, Fauna Hawaiiensis, p. 306.—*Achatinella melanostoma* Newcomb, P. Z. S., 1853, p. 132, pl. 22, f. 7 (1854).—Pfr., Monogr., iv, 521.—*Achatinella limbata* Gulick, Ann. Lyc., vi, 252, pl. 8, 70*a*, 70*b* (Feb., 1858).—*Helicteres byronensis* (Gray), Beck, Index Molluscorum, 1837, p. 51.

A. byronii, in its southeastern forms, is closely related to *A. viridans* and *A. decipiens*. All have more or less corrugated varieties, and others almost smooth.

The type of *A. byronii* was defined only by a figure, but this is of such excellence that no doubt of its identity can be entertained. The shell was presumably brought to England by Lord Byron, whose mission to Oahu in 1824 has been noted in Vol. XXI, p. 157. All of his *Achatinellidæ* were from near the west end of the main range, Wahiawa to Kawailoa. The present species does not occur in Kawailoa district, but it is to be found at Kalaikoa and Ahonui, places in Wahiawa district, a few miles southward. I select Ahonui as the type

locality, pl. 27, figs. 1, 1*a* representing typical shells. The chestnut subsutural band is invariable in Ahonui and Kalaikoa shells.

In a lot of 68 from Ahonui, Gulick coll., the colors are as follows:

1. Typical, green-streaked (pl. 27, figs. 1, 1*a*), 16 shells.

2. Yellowish or olivaceous tawny, clear or more or less roughened and streaked with black (figs. 1*b*, 1*c*), 18 shells.

3. Like 1 or 2, but having spiral bands, at periphery and midway between sutures, sometimes not extending to the last whorl (fig. 1*d*), 33 shells.

4. One shell (fig. 1*e*) has a peripheral band only.

The above division is somewhat arbitrary, as the patterns and colors blend in some specimens.

In Kalaikoa a large series from Gulick contains no bright-green shells. Olive-green, with pattern no. 1 (above), and pattern no. 2 and no. 3 predominate. There are a few dark chestnut shells (pl. 27, fig. 3). The shells are decidedly rough.

Achatinella limbata Gul., from Ahonui and Kalaikoa is identical with the typical green and yellow forms of *byronii* shown in figs. 1 to 1*c*, having the same subsutural line, etc. It is described as "striate, sometimes rugose, green or yellow; apex rose, frequently faded in mature specimens; . . . peristome black." "It differs from *A. melanostoma* Newc., in being more rugose, with rose-colored apex and subangulated body-whorl." Gulick subsequently (P. Z. S., 1873, p. 91) conceded the identity of *limbata* with *byronii*.

4*a*. A. BYRONII RUGOSA Newcomb. Pl. 29, figs. 22, 22*a*; pl. 27, figs. 8 to 10*a*.

"Shell dextral, conical, glossy; whorls 6, rounded, margined above; suture well impressed. Lip expanded, of a reddish-brown at the margin, thickened near the edge. Columella white, short, twisted, and with a strong callus spread over the umbilicus. Aperture subrhomboidal. Striæ longitudinal, numerous, and on the last whorl rugose. Color of epidermis of a deep green, a light or dark umber, sometimes alternating and arranged with the striæ, with or without pale green trans-

verse lines. Length fourteen-twentieths, diam. eight-twentieths inch " (*Newc.*).

Oahu: Ewa (Newcomb); Waimalu, Waiawa, Waipio (Gulick).

Achatinella rugosa Newc., P. Z. S., 1853, p. 138, pl. 22, f. 22, 22*a*, 1854.—Pfr., Monogr., iv, 521.—Sykes, Fauna Hawaiiensis, p. 309.—Thwing, Orig. Descript., pl. 1, f. 24.—*Bulimella rugosa* Lyons, Hawaiian Almanac and Annual for 1892, p. 104, pl. 1, f. 2.

Newcomb's original figures are reproduced, pl. 29, figs. 22, 22*a*. They are like the shells collected by Gulick in Waiawa valley (pl. 27, fig. 8), which is probably what Newcomb meant by " Ewa."

This race inhabits valleys and ridges mainly southeast of those occupied by *byronii*. It differs from that by having the last whorl usually *more strongly corrugated, the lip-callus thinner, the whole lip of a brownish flesh-tint*, at least typically, and *the shell has the gloss of fresh varnish*.

There are, of course, specimens which taken by themselves could hardly be classified correctly; occasional individuals may be smooth or nearly so. The occurrence of almost black (brown-black or green-black) shells in most colonies of *rugosa* is characteristic, since *byronii* is rarely if ever so dark. The embryonic whorls are grayish-buff, flesh-colored or white.

The color-patterns are: (1) greenish-yellow, profusely streaked with green, or yellow streaked with brownish-olive, either plain or with two spiral brown bands and a subsutural band, (2) last whorl black or nearly so. There are also intermediate specimens connecting the darkest and lightest.

In a lot from Waimalu there are no banded shells (pl. 27, figs. 9, 9*a*). This place must be at or near the extreme southeastern limit of the species. Waiawa shells are very often banded, and with a small proportion of the blackish form (pl. 27, fig. 8). In a lot from Waipio the blackish-chestnut form predominates (pl. 27, figs. 10, 10*a*). All the preceding are from the Gulick collection, and probably all of them were taken at rather low elevations.

Length 19.3, diam. 10.2, aperture 9 mm.; 6¼ whorls. Waipio.

Length 17.5, diam. 10 mm. Waipio.

Length 18.2, diam. 9.4, aperture 8.7 mm. Waiawa.

Length 16.3, diam. 10, aperture 8.8 mm. Waiawa.

In Dr. C. M. Cooke's collection there is a lot of 9 specimens (no. 1828-30) agreeing entirely with some of Gulick's Waimalu *rugosa* (such as pl. 27, fig. 9*a*), said to have been collected in " a very small and extremely isolated clump of trees on the extreme S. slope of the Waianae range,"—in the region of Palihua. As the collector was a person knowing nothing of shells, I cannot help suspecting that he got a Koolau range lot confused with his Waianae catch. The shells are greenish-black with the first neanic whorl green or olive streaked on a yellow ground, embryonic whorls deep livid purple in some, white in other examples. They have the gummy gloss of *rugosa*.

1. Subvariety *capax* Pils. & Cooke. Pl. 31, figs. 7, 7*a*, 7*b*. At the head of Waiawa gulch, along the Waiahole-Waiawa ditch trail, ¼ mile from top, Mr. Spalding collected large, robust specimens, less wrinkled than the typical form. The shell is streaked with olive and yellowish-olive on a lime-green ground, often with chestnut bands at periphery and base. The lip is either pure white or narrowly bordered with purple or brown; embryonic whorls either flesh-pink or bicolored, a brown zone above, white below. They were on banana and ieie. The colony was found to extend as far as the Kipapa division ridge, and probably goes farther north. There is but little variation in color and shape, and it is invariably dextral. The patterns are shown in figs. 7-7*b*.

Length 21, diam. 12.5, aperture 11 mm.; 6 whorls.

Length 19, diam. 10.5, aperture 9.2 mm.

2. Subvariety *waimanoensis* P. & C., new. Pl. 31, figs. 9 to 9*d*. On the crest of the Waimano-Manana ridge, a half mile to a mile above the locality of *A. t. cookei*, there is a dextral *pulcherrima*-like shell, with ground of almost white, buff, or greenish yellow, plain or with chestnut bands in the typical *rugosa* positions, or variously split into lines; lip white or pale lilac. Surface much smoother than in *rugosa*. Embryo white, or in the darkest shells, light brown or bicolored. All seen are dextral.

Length 17.8, diam. 10.7, aperture 9 mm.

Length 15.5, diam. 9.5, aperture 7.5 mm.

Through the darkest specimens, this race seems to connect with the more wrinkled small form of *rugosa*, no. 3.

3. At the lower edge of the above colony, just above the locality of *A. cookei*, there is a diminutive race similar to the preceding in shape, but more strongly wrinkled, with the color-patterns of subvar. *capax*; also a few very deep chestnut shells. The narrow lip is purple, and the upper whorls flesh pink. Length 17, diam. 9.8, aperture 8.3 mm., 5½ whorls. Pl. 31, figs. 8, 8*a*.

Forms 2 and 3 were collected Feb. 17, 1913, in company with Messrs. Spalding and Merriam.

4*b*. A. BYRONII NIGRICANS n. subsp. Pl. 31, figs. 10, 11, 12.

The shell is *sinistral*, oblong-conic, rather solid. Embryonic 3 whorls snow-white, the next whorl brown, or brown and green, with a light band, *last whorl intensely black* above, but on close inspection showing very indistinctly a dusky greenish-yellow band at periphery and a wider one on the base. The surface of the last two whorls is rather coarsely wrinkled, and has a brilliant gloss. The aperture is very oblique, ovate, white or with a faint lilac tint within; peristome has a narrow callous rib within of a fine purple color, changing to violet at the lip-edge. Columellar fold purple with white tip or crest. Parietal wall deep purplish brown.

Length 17.4, diam. 11, aperture 9 mm.; 6⅓ whorls.

Length 21, diam. 12.3 mm.

Waimano-Manana ridge at about 1400 ft. elevation, in a very small area along the summit trail (Spalding, Merriam, Pilsbry, Wilder).

This form differs from *rugosa* Newc. by its capacious form, coloration and sinistral coil. The last character would not be of much significance were it not that the whole *byronii-rugosa* series is dextral, in hundreds of individuals which have been examined from many localities. A snow-white embryo is also occasionally seen in *rugosa*. *A. b. nigricans* is doubtless a derivative from *rugosa*.

It lives in a clump of lehua trees alongside of the trail, about 1000 yards down the ridge from the locality of *A. turgida cookei.* The colony is a very small one.

In Mr. Wilder's collection there are some *nigricans* from the type colony distinctly banded with green on the last whorl.

Mr. Spalding also found three specimens on a large mokihana bush on a lateral spur of the ridge about 100 yards *mauka* from the locality of *A. t. cookei.* One of these specimens, fig. 10, is larger than those from the lower station. The upper post-embryonic whorl is green, banded with brown.

It is a rare and handsome shell, possibly deserving specific rank. There is a black form of *A. turgida* which has an astonishing resemblance to *nigricans*, but differs by being smoother with the real *turgida* apex, that of *nigricans* being quite different.

So far as known, this subspecies is restricted to very few small trees, in two spots less than a mile apart.

5. A. LILA Pilsbry, n. sp. Pl. 31, figs. 15 to 15*d*.

The shell is sinistral, ovate-conic, thin but strong, *nearly smooth, brilliantly glossy.* The embryonic whorls are burnt sienna brown (weathering to whitish in adult shells) or sometimes there is a light median zone. Last whorl either (fig. 15*d*) uniform blackish chestnut, or (fig. 15) having a chestnut peripheral band and baso-columellar patch on a yellow ground, or (figs. 15*a*, *b*) like the last but with a green band midway between periphery and suture, or (fig. 15*c*) with sutural and peripheral bands and baso-columellar patch of yellow on a chestnut ground. There are also a few specimens more or less intermediate between the patterns of figs. 15 *a*, *b*, *d*. The aperture is moderately oblique, white or faintly lilac within; peristome acute, *very little or not perceptibly thickened* within; columellar fold strong, purple or white.

Length 17, diam. 11, aperture 9 mm.; 5½ whorls.

Length 16.8, diam. 10.2, aperture 8.8 mm.

Length 16, diam. 15.3 mm.

Oahu: crest of the Waimano-Manana ridge at junction with

the main range, running from the summit down about three-fourths of a mile along the ridge trail; in axils of ieie (Spalding, Merriam and Pilsbry). Types no. 108066 A. N. S. P. Cotype in Bishop Museum.

This charming shell has a great resemblance to *A. abbreviata* of the eastern end of the range, from which it is separated by about a fourth of the length of the island, wherein no related forms have been found. *A. abbreviata* is invariably dextral, *A. lila* sinistral. There are also differences in the patterns of the banded forms. It is likely that *A. lila* is more closely related to *A. nigricans*, and therefore a derivative of the *byronii* group of species, and not directly related to *A. abbreviata*. The color-pattern 15*c* is a "negative" of 15*a*, the light and dark areas being reversed. In treating of the genus *Liguus* I have noted similar instances.

In the type lot the colors are in the following numbers: Pattern of fig. 15, 1 specimen; figs. 15*a*, *b*, 8; fig. 15*c*, 5; fig. 15*d*, 10. Four of the lot have the columellar fold white.

A. lila is rather abundant on its misty peak, but soon becomes rarer and disappears as one descends the trail into less cloud-hung levels. Near the summit only the black form is found, the beautifully green-banded shells occurring lower on the trail, where there are few of the black ones. The lateral slopes of the ridge drop so precipitously that collecting is almost restricted to what may be reached from the trail. On the north side of the peak a *pali* of a couple of thousand feet permits collecting only close to the summit. Named for L. L. C.

6. A. PULCHERRIMA Swainson. Pl. 27, figs. 2 (Ahonui), 5-5*g*, 6 (Wahiawa); pl. 31, figs. 13 (Kawaihalona), 14 (Helemano).

"Shell ovate-oblong, subcylindical; white or yellow with broad bands of chestnut; margin of the lip brown. Var. *a*, golden yellow, suture chestnut. This very elegant species is about 0.8 inch long, and is much more slender than any of the preceding. It varies somewhat in form, some specimens being more ventricose than others, and also in the number and color of its bands. The ground color is a deep and rich chestnut,

with from one to three bands of orange, yellow, fulvous or white. The marginal groove to the suture is very close and distinct in all. The golden yellow variety is without bands. In all the colors are remarkably rich and vivid'' (*Swainson*).

Oahu: Waialua (Newcomb); Helemano, Wahiawa, Kalaikoa and Ahonui (Gulick); Helemano, low down, and eastern spurs of Kawaihalona (Irwin Spalding).

Achatinella pulcherrima Swains, The Quarterly Journal of Science, Literature and Art, The Royal Institution of Great Britain, January to June, 1828, p. 86; Zoological Illustrations, iii, Second Series, 1832-3, p. 123, pl. 123, f. 2.—Pfr., Monographia ii, 237; iii, 460; vi, 172; Conchyl. Cab. p. 280, pl. 67, f. 30, 31.—Newcomb, Ann. Lyc. vi, 308.—Thwing, Orig. Descript. pl. 1, f. 18.—*Bulimella p.*, Lyons, Hawaiian Almanac and Annual for 1892, p. 105, pl. 1, f. 6.—*Achatinella lorata* Fér., Reeve, Conch. Icon. pl. 1, f. 6, 1850.—*Achatinella melanostoma* Newc., P. Z. S. 1853, p. 132, pl. 22, f. 7.—*Achatinella multicolor* Pfr., in part, P. Z. S. 1855, p. 4, pl. 30, fig. 11 (not fig. 11*a*).—*Achatinella mahogani* Gulick, Ann. Lyc. Nat. Hist. of N. Y. vi, p. 254, pl. 8, fig. 72.

This species differs from *byronii* chiefly by its *smooth surface*. The last whorl is more evenly rounded, while in *byronii* it is often subangular. The pattern of Swainson's left-hand figure was selected by Pfeiffer as typical. It is shown in our pl. 27, fig. 5*c*; also pl. 31, fig. 13. There are two broad chestnut zones on a yellow ground. This happens to be a rather rare color-form which however occurs in Gulick's Wahiawa series (fig. 5*c*), and has been collected by Mr. Spalding on the eastern spurs of Kawaihalona (pl. 31, fig. 13). I take the latter valley as type locality, since it was certainly from shells taken in that neighborhood that Lord Byron's lei of Achatinellas was made. The lip is obtuse, black-brown, with a whitish rib within. The glossy surface has exactly the character of that of *nympha*, etc. All of the large series examined are dextral. Color-forms of a lot from Wahiawa (Gulick), are as follows.

Pl. 27, fig. 5*c*. Two broad chestnut zones on a yellow ground; sutural line usually chestnut.

Pl. 27, figs. 5*d*, 5*e*. Two narrow chestnut bands or lines; rarely some additional lines. One or both lines may be wanting on the last whorl.

Pl. 27, fig. 5*f*. Yellow, without bands except the sutural (Swainson's var. *a*); or with a white sutural border, fig. 5*g*.

Pl. 27, fig. 5, 5*a*, 5*b*. Chestnut, with or without darker bands.

Length 18.5, diam. 9.3 mm.

Length 19, diam. 10 mm.

Length 20, diam. 11.2 mm.

Length 17, diam. 10 mm.

In Helemano and Waialua district, the northwestern limits of *pulcherrima*, the same forms occur. Those of Kalaikoa do not differ noticeably. In Ahonui part of the lots examined are like those of "Wahiawa." In others there are many whitish shells with a gamboge tint, with or without dark lines. Also a lot of shells varying from chestnut to sulphur-tinged yellow, with sutural band only, many of them stouter in form than typical *pulcherrima*. Length 18.5, diam. 11.5 mm. These lots are from the Gulick collection. Pl. 31, fig. 14 is from low in Helemano, coll. by Spalding.

Judging from the description and figure of *A. melanostoma* Newc., as well as from specimens received from him, it is a synonym of *pulcherrima*, being based upon a somewhat different color form from that of Swainson, though occurring with the typical color-form in Wahiawa district. Newcomb's locality, Ewa, refers to the district, which takes in the extreme southeastern part of the range of *pulcherrima*. The original description follows.

A. melanostoma Newc. (pl. 29, fig. 7, reproduction of original figure). "Shell dextral, polished, solid conical; whorls 6, plano-convex, slightly margined above; suture moderate, accompanied with a black revolving band. Aperture subovate; lip black, thickened within. Columella short, brownish-red, terminating abruptly in a strong plait or tuberosity. Color yellowish or umber, with or without transverse brown lines. Length fourteen-twentieths, diam. seven-twentieths inch. Ewa, Oahu" (*Newcomb*).

According to a note from Mr. Spalding, *melanostoma* is now found only in the northern branch of Kipapa; but I do not know just what form he found so far east.

A. multicolor Pfr., Pl. 30, fig. 11, reproduction of original figure. "Shell dextral or sinistral, imperforate, conic-oblong, solid, striate, and under the lens most minutely decussated, glossy; buff or whitish, variously ornamented with blackish-chestnut bands, rarely unicolored. Spire long-conic, towards the apex somewhat attenuated, rather acute; suture margined. Whorls 6, rather flat, the last about two-fifths the total length, rounded basally. Aperture oblique, truncate inverted ear-shaped; columellar fold above, strong, twisted. Peristome black-edged, the outer margin somewhat straightened, narrowly expanded; columellar margin dilated, subadnate. Length 17, diam. 9 mm., aperture 8½ mm. long, 4½ wide. Sandwich Is., Frick in Cuming coll. (*Pfr.*).

In the above description Pfeiffer obviously confused two species. His two figures, reproduced in my pl. 30, figs. 11, 11*a*, belong to *A. pulcherrima* (fig. 11) and *A. sowerbyana oviformis* (fig. 11*a*). Doctor Hartman recognized the latter and added *A. oviformis* to the synonymy of *multicolor*; but he included Pfeiffer's fig. 11, and therefore did not restrict the species or realize its dual composition (Proc. A. N. S. Phila. 1888, p. 30). Mr. Sykes referred Pfeiffer's fig. 11*a* to *A. oviformis*, and fig. 11 to *A. recta* Newc., which he ranks as a variety of *A. byronii*. As several of Pfeiffer's phrases, particularly "*perist. nigrolimbatum*" apply best to his dextral shell, I would restrict *A. multicolor* to fig 11. It becomes therefore an absolute synonym of *A. pulcherrima*, having the typical color-pattern, which seems to have been more common in the lower forests of three-quarters of a century ago than it is now. *A. recta* Newc., which Mr. Sykes and others have confused with the present group, belongs in the series of *A. livida*.

Form *mahogani* Gulick (pl. 27, figs. 4 to 4*d*, Ahonui). This form has the smooth surface of *A. pulcherrima*, merely marked with growth-lines, not corrugated or wrinkled. A subsutural dark band is often wanting, or not darker than the rest of the

shell, which is nearly free from dark streaks. The lip has a narrower black edge than well-colored *byronii,* and has a white rim within. The figures, from a large set in the Gulick collection, show the range of color—from mahogany to yellow, with or without bands. Except in the usually darker coloration, I can see no reason for separating *mahogani* from *pulcherrima.* Gulick's description follows. His figure is like pl. 27, fig. 4*a*, which is exactly like the type-specimen.

"*Achatinella mahogani.* Shell dextral, imperforate, turreted, solid, shining, striate, reddish chestnut; apex obtuse, rose; spire concavely turreted; suture lightly margined, moderately impressed; whorls 6, convex, the last inflated, with the base black-chestnut and regularly rounded; columellar fold central, white, strong; aperture truncately auriform, white within, with external margin scarcely reflected anteriorly, arcuate; columellar margin dilated, adnate; parietal margin wanting. Length 20.6, breadth 11, length of body-whorl 12 mm. Average weight 8 grains.

"On trees, Ahonui and Kalaikoa, J. T. G. It lacks the black color of lip and suture which characterizes *A. melanostoma* Newc. and *A. limbata* Nob., and also differs in the general form and color" (*Gulick*).

A form which would be referred to *mahogani* if it occurred on the south side of the main range is in the Gulick collection (no. 125; no. 92461 A. N. S. P.), with the locality Kahana. It is not unlike Pfeiffer's figure of *A. planospira* except that the base is not abruptly darker as in that figure. It differs from Kahana *decipiens* by having light brown early whorls instead of white.

6*a*. A. PULCHERRIMA NYMPHA Gulick. Pl. 32, figs. 13, 14; pl. 27, figs. 7, 7*a*, 7*b*.

"Shell dextral, imperforate, oblong-ovate, solid, shining, very lightly striated, yellow or chestnut, sometimes lined with brown." Interior and columellar fold white. Peristome well thickened within close to the edge, white, or in banded shells showing marginal spots. Dark chestnut shells have a narrow dark lip-border. Length 18.5, diam. 10 mm.

Oahu: Ahonui, Kalaikoa, Wahiawa, Helemano, Opaeula, Kawailoa and Waimea (*Gulick*).

Achatinella nympha Gul., Ann. Lyc. Nat. Hist. of N. Y., vi, 251, pl. 8, f. 69, 1858.

Merely a variety of *pulcherrima*, from which it differs by the *white lip*, which however is dark-edged in some examples of Gulick's lots. It differs from *recta* by the conspicuous thickening of the lip. Some of the large lot in the Gulick collection have a narrow dark sutural band, but most of them have none, and in some the suture has a white border. In a lot from Wahiawa the patterns are in these numbers: yellow ground bandless 6, with bands or lines 25; chestnut ground, bandless 20, banded 9 shells.

According to Gulick, Helemano is the metropolis of *nympha*. The specimens figured are from Helemano (pl. 32, fig. 14) and Wahiawa (pl. 27, figs. 7, 7*a*, 7*b*; pl. 32, fig. 13). Fig. 13 is too deep in color. The shell is much lighter, what Ridgway calls barium yellow. Pl. 27, fig. 5*g*, might be referred to *nympha* as well as to *pulcherrima*.

Dr. Cooke, who examined the type of *A. aptycha* Pfr. (see p. 54), considers it a form of *nympha*. The figure is reproduced in my pl. 30, fig. 1.

7. A. DECIPIENS Newcomb. Pl. 32, figs. 2 to 6*c*.

"Shell conically-elongate, solid; whorls 6, slightly rounded, margined above. Aperture elongately-ovate; lip subreflected; columella short, obliquely twisted, with an expanded callus. Suture slightly impressed; striæ numerous, longitudinal, oblique. Color white with yellow transverse bands, or yellow with white transverse lines and longitudinal chestnut colored stripes. Length sixteen-twentieths, diam. seven-twentieths inch" (*Newcomb*).

Oahu: Kahana (Newcomb); Hakipuu (Gulick for *A. corrugata*).

Achatinella decipiens Newc., P. Z. S., 1853, p. 153, pl. 24, f. 68, 1854.—*Achatinella corrugata* Gulick, Ann. Lyc. N. H. of N. Y., vi, p. 248, pl. 8, f. 66, 1858.—*Achatinella torrida* Gul., Ann. Lyc. N. H. of N. Y., vi, p. 250, pl. 8, f. 68, Feb., 1868.

A. decipiens (including *torrida* and *corrugata*) represents *A. byronii* on the northeastern side of the Main Range in the valleys from Waikane to Kahana. As we do not know what forms occur on top, and whether there is complete intergradation there, the races from the windward side are for the time treated as a species distinct from *byronii*. It differs from *byronii* by having the lip entirely or mainly white and by having part of the patterns different.

Newcomb's typical lot consisted of shells resembling pl. 32, figs. 2, 2*a*, from examples received from him; fig. 2*a* representing the pattern of his type figure. The shell is yellow, profusely streaked and lineate with deeper yellow and chestnut along growth-lines, having a white zone below the suture and typically another at the periphery; spire mainly white, lip and aperture also white. Under a hand-lens the surface is seen to be quite distinctly striate spirally, with a finer descending wrinkling such as is usual in *Partulina*, but this varies in distinctness a good deal, among the specimens from Newcomb himself, on some of which it would not be noticed if not especially looked for. Length 18, diam. 10 mm.

In other Kahana lots, collected by Gulick, the patterns vary somewhat (pl. 32, figs. 3 to 5). Olive-green or yellowish-green may take the place of chestnut streaking. The surface, typically almost smooth, may be rather distinctly corrugated in some shells. These pass directly into the form called *corrugata* Gulick.

Length 23, diam. 11 mm.

Length 17, diam. 10 mm.

Length 16.3, diam. 9 mm. (rough, stunted shell).

In another Kahana lot the prevalent color is light yellowish-green, faintly streaked, and fading to whitish near the suture and on the spire (pl. 32, fig. 3*b*). Other shells are broadly banded with chestnut, glossy like the preceding; lip tinted (pl. 32, fig. 4*a*). Another pattern occurring sparsely in this and other Kahana lots is dull yellowish, copiously streaked with chestnut and blackish, and having two spiral brown bands. It is almost lusterless and somewhat corrugated.

It is evident that Gulick did not collect in Newcomb's type colony of *decipiens*, which may have been of small extent.

Achatinella corrugata Gulick from Hakipuu (pl. 32, figs. 7, 7*a*, 7*b*) seems to me to be almost identical with *decipiens*, from which it differs chiefly by the usually more corrugated surface, which shows only very indistinct traces of minute spiral sculpture. The color-patterns resemble the streaked forms of *torrida* except that none in the large lot has a white subsutural band, such as *torrida* and *decipiens* often possess. Gulick's type is streaked with olive-green on a pale-green ground (pl. 32, fig. 7*a*). Others are streaked with chestnut on a yellow ground, with or without one or two spiral chestnut or blackish bands, while still other shells are brownish-black with a white summit. None has spiral white bands, and very few have two chestnut bands. Gulick remarks that sinistral examples have been found. I have noticed one in the lot of several hundred shells from his collection. The original description of *corrugata* follows.

" Shell dextral, imperforate, ovate, solid, shining, striated, green; apex subacute, pale; spire convexly conic; suture margined, moderately impressed; whorls 5½, convex, the last rugose; columellar fold central, white, strong; aperture truncately auriform, white within; peristome thickened within, white, sometimes margined with brown, with external margin dilated, adnate; parietal margin wanting. Length 18⅓, diam. 10 mm.; average weight 5.3 grains. Hakipuu, Oahu, on trees. The color is often nearly black, and sometimes reddish-yellow " (*Gulick*).

A rather large shell measures, length 19.1, diam. 10.8 mm.; a very narrow blackish one, length 18, diam. 8.5 mm. (fig. 7*b*).

Another colony from Hakipuu was correctly considered by Gulick to be transitional to *decipiens* proper. Some specimens have a white sutural band, and occasionally there is a white line at the periphery (pl. 32, figs. 6 to 6*c*).

Variety (?) *planospira* Pfeiffer. Pl. 30, fig. 8.

Achatinella planospira Pfr. has been placed in the synonymy of *decipiens* by Newcomb, who is followed by Hartman, Sykes and Thwing. I have seen specimens of form *corrugata* having the same pattern except that the summit is light, while Pfeiffer's figure shows it dark. The status of the

form is therefore uncertain. It needs comparison with *pulcherrima* and *mahogani*. There is, however, a lot of *mahogani*-like shells in the Gulick collection (no. 125) from Kahana, having the apex dark, and agreeing fairly well with *planospira*.

The original account follows. *A. planospira* Pfr. (pl. 30, fig. 8, photographically reproduced from Pfeiffer's plate). "Shell dextral, imperforate, ovate-pyramidal; solid, closely striate and under the lens very obsoletely striate spirally, glossy; blackish, ornamented with several narrow white or buff bands. Spire conic, rather acute; suture linear, margined. Whorls 5½, flat, the last a little shorter than the spire, obsoletely angular, rounded basally. Aperture oblique, inverted ear-shaped. Columellar fold above, strong, twisted, white. Peristome thickly white-lipped, the right margin spreading, narrowly expanded, columellar margin adnate. Length 19, diam. 9½ mm., aperture 9 mm. long, 4 wide. Var. *b*, above blackish-chestnut, the last whorl tawny, with brown lines. Sandwich Is., Frick in Cuming coll" (*Pfr.*).

Variety *torrida* Gulick. Pl. 32, figs. 8 to 12*c*.

The sinistral form of *corrugata* was described as *A. torrida* by Mr. Gulick. The distinction from *corrugata* is rather too vague to rank it as a subspecies, though there is a certain amount of racial differentiation. Its patterns differ in many specimens, and then most *torrida* are sinistral. The original account follows.

"Shell sinistral, imperforate, ovate-conic, solid, shining, somewhat rugose, green or fulvous; apex subacute, chestnut; spire conic; suture lightly margined, white, moderately impressed; whorls 6, convex; columella with a strong white fold near the body-whorl. Aperture oblique, truncately auriform, white within; peristome white, thickened within, with external margin scarcely reflected anteriorly, slightly compressed; columellar margin dilated, adnate; parietal margin wanting.

Length 17⅓, breadth 9⅔ mm.; average weight 4.5 grains" (*Gulick*).

"Var. *b*, with black spiral lines. I am in doubt concerning the limits of variation of this species; var. *b* may be distinct" (*Gulick*).

Oahu: Kahana, Kaaawa and Waikane (Gulick); Waiolu (J. S. Emerson).

Waiolu may be considered the type locality, as here the typical form (pl. 32, figs. 11, 11*a*, 11*b*) occurred. It is closely streaked with rather dull-green or chestnut on a light ground, the streaks sometimes confluent. A wide subsutural white band (often denuded of cuticle) is frequently present. The apex is not chestnut, as Gulick states, in any of the lot of over a hundred from his collection, from all the localities mentioned above. Six out of a set of 56 from Kahana are dextral, all others seen being sinistral. Specimens with streaked pattern are almost mirror images of *A. decipiens*, but they differ by having the aperture a little more oblique, the lip is usually a trifle less thickened within, and the surface in the average *torrida* is more corrugated. The lip usually has a fleshy or brownish border. Specimens from Kaaawa (pl. 32, fig. 9) are similar to those of Waiolu.

A small set from Waikane is strongly corrugated, heavily streaked, with a dark band below the suture (pl. 32, fig. 8).

In Kahana the shells are variable (pl. 32, figs. 10 to 10*d*). Those having blackish streaks on a yellowish or chestnut ground resemble forms of other valleys. Others have one or two black-brown zones and a white sutural band; and in some the blackish-chestnut color spreads over all but the earliest whorls. The surface has very little gloss in this lot. Kahana specimens in coll. C. M. Cooke are similar except that the ground-color is greenish and the surface glossy.

Length 18, diam. 10.7 mm. Kahana.

Length 18.5, diam. 10.5 mm. Kahana.

Length 17, diam. 10 mm. Kahana.

Length 17.5, diam. 10 mm. Waiolu.

Kaaawa-Hakipuu division ridge (pl. 32, figs. 12 to 12*c*). In a very handsome series collected by Mr. Spalding the embryonic whorls are light-brown, differing thus from the large series of *torrida* in Gulick's collection, in which the early whorls are white or nearly so. The last whorl, fig. 12, is green streaked with a much darker shade, or similar, with two black bands and a white sutural band. Fig. 12*c*, black with a yellow

band and white line at the suture. Fig. 12*a*, chocolate. The lip is dark-edged, or in form fig. 12*c* has two spots at the terminations of the bands. The surface is rather rough. This colony is mainly sinistral, but there are some dextral shells.

7*a*. A. DECIPIENS KALIUWAAENSIS Pilsbry & Cooke, n. subsp. Pl, 32, figs. 1, 1*a*, 1*b*.

The shell is similar to *decipiens* but smoother, *more glossy*, with only obsolete traces of sculpture. Color various: (*a*) White with a brownish sutural line. (*b*) Olive-ocher with a white zone below the suture and a white line at periphery. (*c*) Olive-ocher with a chestnut subsutural line or none, and a pale peripheral line. Lip only narrowly thickened within, white.

Length 19.2, diam. 10, aperture 9 mm.

Length 17, diam. 9.7, aperture 8 mm.

Length 15.3, diam. 8.9, aperture 7.6 mm.

Eastern ravines of Kaliuwaa, type loc., also central and western ravines (Irwin Spalding).

This new form has such a relation to *decipiens* as *pulcherrima* to *byronii*. The locality lies some distance northwest of that of *decipiens*, in a district where the other Bulimellas differ from the Kahana forms. The coloration is much like that of typical *decipiens*. The white-banded form may be considered the typical pattern. The cotypes are in coll. A. N. S. P. and Bishop Museum, collected by Mr. Spalding who has a long series. It is also in the Thaanum, Thurston and some other recently gathered collections.

7*b*. A. DECIPIENS (?) SWAINSONI Pfeiffer. Pl. 30, fig. 13.

"Shell sinistral, imperforate, ovate-conic, solid, nearly smooth, glossy; whitish, delicately streaked with tawny. Spire conic, apex fulvous, rather acute; suture margined. Whorls 5½, a little convex, the last nearly equal to two-fifths the length, swollen below the suture, rounded at base. Aperture slightly diagonal, reversed auriform. Columellar fold superior, strong, nodiform; peristome bordered with black-brown, the external margin a little reflected, thickly labiate within;

columellar margin thick, flexuous, adnate. Length 20, diam. 11 mm.

"*b*. Greenish buff, the last whorl chestnut anteriorly" (*Pfr.*).

Sandwich Islands, Frick, in coll. H. Cuming (*Pfr.*).

Achatinella swainsoni Pfr., Proc. Zool. Soc. Lond., 1855, p. 4, pl. 30, f. 13.

Dr. Cooke, who examined the type, thought this a sinistral individual of *A. pulcherrima*. "Newcomb suggested that this might be only a form of *A. sordida*; it appears however to be distinct, being broader, brown in general coloration, and having a brown in place of a white lip. It is a little doubtful from its form if it be correctly placed in this group [*Achatinella s. str.*], but the sections are very artificial" (*Sykes,* Fauna Hawaiiensis, p. 304). As I have not seen the shell, I cannot properly express an opinion; but from the figure it seems as near the *torrida* form of *decipiens* from the Kaaawa-Hakipuu ridge as anything, and I put it here for want of a better place. It may be noted that several enigmas of Frick-Pfeiffer origin were from the Koolauloa district. We know very little about Frick, but from what he got we may infer that the country between Kaneohe Bay and Kahuku was one of his collecting grounds.

Series of A. bulimoides.

Rather large, compact, capacious shells, smooth, never streaked with green, usually banded. This series comprises numerous forms on both sides of the western half of the Main Range.

8. A. rosea Swainson. Pl. 34, figs. 1 to 8*b*.

"Shell reversed, pale rose-color, with obsolete white bands. I place this, for the present, as a variety of the last [*A. bulimoides*] to which, except in being reversed, it bears a close resemblance in size, form and general habit. It is entirely of a pale and delicate rose-color, with two obsolete bands of white on the body-whorl. The margin of the lip and columella are of a deeper rose-color, and the aperture white. It should

be observed that the marginal [subsutural] groove, which is scarcely perceptible in the last, is in this very distinct" (*Swainson*).

Length 22.3, diam. 13.5 mm.; 6⅓ whorls.

Length 23, diam. 13 mm.

Length 19, diam. 12 mm.

Oahu: Helemano and Poamoho to Kaukinehua; formerly, according to Gulick, from Kawailoa to Ahonui.

[*A. bulimoides*] var. ?—(*rosea*) SWAINSON, The Quarterly Journal of Sci., Lit. and Art, January to June, 1828, p. 85.—*Achatinella rosea* SWAINS., Zoological Illustrations, III, 2d series, p. 123, pl. 123, f. 2.—REEVE, Conch. Icon., vi, pl. 4, f. 28.—PFR., Monogr., ii, 236; iii, 456; iv, 518; vi, 163.—THWING, Orig. Descript., p. 93.

A. rosea is invariably sinistral. It further differs from *A. bulimoides* by being smoother, more glossy. The color varies widely, but the older collectors found only the white and pale-rose forms, which, from the large series in old collections, must have been abundant in the time of Newcomb and Gulick. Figures 1*a* to 2*a* represent the usual color-forms of the species, the other forms figured being more or less rare. It evidently extended lower than the dark-colored forms, in a zone now barren by the recession of the forests. Gulick's localities—none of them more exactly located than by the valley or district—were Wahiawa, Waialua, Helemano (pl. 34, figs. 1, 1*a*), Opaeula and Kawailoa, all of the many specimens being white or pale-rose or light rosy-brown, with roseate lip, the colonies apparently homogeneous except for these fluctuations of tint.

According to Mr. Spalding the headquarters of white or nearly white *rosea* are in Helemano, but it is found from Kawailoa to Kaukinehua in the Wahiawa district. There are many gradations of tint between the white shells, the faint rose, and the rose with white bands. An albino form with the lip pure white has been taken by Mr. Spalding in a small ravine in the eastern edge of Helemano, just above the forest limit, similar to pl. 34, fig. 1, Helemano, Gulick coll.

A. rosea varies a good deal in size and shape. Typically colored shells from Wahiawa, Gulick, measure:

Length 22.3, diam. 13.6, aperture 11.5 mm.; 6½ whorls.
Length 22.7, diam. 13, aperture 10.7 mm.
Specimens of a lot from "Waialua," Thaanum, measure:
Length 21.7, diam. 12.3, aperture 10.5 mm.; 6½ whorls.
Length 21.5, diam. 12, aperture 10.5 mm.
Length 18.3, diam. 12.4, aperture 10 mm.
Length 17.3, diam. 10, aperture 8.3 mm.; 6 whorls.

Specimens from Ahonui in Mr. Thaanum's collection are white and pink, the usual coloration.

Messrs. J. S. and Oliver P. Emerson collected quantities of dark-red *rosea* in the ravine in which the Waialua plantation built its Kamoku reservoir, next west of Opaeula. This was over fifty years ago, and the colony has been extinct these many years.

On the middle ridge of Poamoho (between the western and central branches of the stream), a colony about a mile above the forest limit contains shells with the last whorl white, white with two rose bands, or rose-tinted with deeper rose bands defining a median white zone. The lip and columellar fold are deep rose color. Pl. 34, figs. 2, 2*a*, coll. by Irwin Spalding. The same form has been given me by Mr. Thaanum, coll. by Mr. Kuhns. A mile further up, just west of the main ridge, the shells have the summit dark; color of last whorl pinard yellow with white suture; the same with tawny bands and spire; yellow ocher with tawny bands and darker spire, or flesh color changing to coral-pink near the suture. In all, the lip is more or less blackish (pl. 34, figs. 6 to 6*c*, coll. by Irwin Spalding). These shells are small, length 18 to 19.5 mm.

In Opaeula, at about 1,700 ft., Mr. Wilder found very dark specimens, last whorl raw sienna with chestnut base, together with pale green-yellow shells, both having the peristome and summit dark (pl. 34, figs. 5, 5*a*). It was probably lower down that Gulick found the ordinary white and pink *rosea* from Opaeula in his collection.

Similar but larger shells were taken by Mr. Spalding in the eastern branch of the north fork of Kaukinehua (pl. 34, figs. 7). Other specimens from the same or an adjacent col-

ony are shown in pl. 34, figs. 8, 8*a*, 8*b*, taken by Mr. Wilder. One measures, length 22, diam. 13.6, aperture 11.3 mm.

In a gulch west of Helemano Mr. Spalding found charming pale green-yellow shells, with geranium-pink lip and faint traces of two pink bands (pl. 34, fig. 4, no. 434 Spalding coll.).

In the bottom of Kawaihalona the shells vary from flesh or salmon color to vinaceous in several tints (pl. 34, figs. 3, 3*a*, coll. by Irwin Spalding; fig. 3*a* being no. 2167 of his collection).

Achatinella rosea is one of the most exquisite of land shells. While the light-colored form is not uncommon in collections, the "green *rosea*," the wine-colored and the dark forms are rare even in Honolulu. They are among the prize specimens of the finest collections. I did not myself collect in the *rosea* territory, which has been thoroughly "shelled" in the last few years, but the generosity of Messrs. Irwin Spalding and W. D. Wilder has made it possible to illustrate the main variations of this charming shell.

9. A. BULIMOIDES Swainson. Pl. 33, figs. 1 to 1*j*, 3 to 4.

"Shell ovate-oblong, subventricose, whitish with chestnut bands; spire thickened, the tip pale brown. Larger than the last [*A. livida*], and of nearly the same form, but the spire is less thickened and more pointed at the apex. The ground-color, in some specimens, is pale chestnut or ferruginous, banded with darker shades and another of pure white. In others the upper half of each whorl is whitish, and the lower chestnut, marked by darker bands. The suture is scarcely if at all margined by a groove. The aperture and pillar white" (*Swainson*).

Oahu: Waialee, Waimea, Kawailoa valley (Gulick). Head of Kaipapau, on the north side of the range (Irwin Spalding).

Achatinella bulimoides SWAINSON, The Quarterly Journal of Science, Literature and Art, The Royal Institution of Great Britain, January to June, 1828, p. 85; Zoological Illustrations, iii, 2d Series, 1832-33, pl. 108, f. 1.—REEVE, Conch. Icon., vi, pl. 1, f. 8, 1850.—HEYNEMANN, Malak. Bl., xiv, 1867, pl. 1, f.

2 (dentition).—Pfr., Monographia, iii, 460; iv, 518; vi, 143; viii, 216.—Thwing, Reprint Orig. Descr., p. 92, pl. 2, f. 1.—Gulick, Evolution, Racial and Habitudinal, p. 41, pl. 3, f. 1-5.

Swainson's figures agree exactly with my pl. 33, figs. 1*b*; 1*d*, from "Kawailoa," which I take to be the type locality. It "has now become a very rare shell," owing to the destruction of forest, but I imagine that it will be found higher up, in the region between Kawailoa, Waimea and Kaipapau.

A. bulimoides is always dextral, imperforate or nearly so, solid; the upper whorls are finely striate spirally and flesh-tinted; the lip is well thickened within and usually white or yellowish, but brown in dark forms. There is never a subsutural dark line as in brown-band forms of *A. rosea,* but the suture is often bordered with an impressed line.

Specimens from Kawailoa measure:

Length 20.6, diam. 12.4, aperture 11 mm.; whorls 5¾.

Length 21.3, diam. 11.8, aperture 11 mm.; whorls 6¼.

In a lot of 48 from "Kawailoa" (pl. 33, figs. 1 to 1*j*, Gulick coll., 92489, A. N. S. P), the following color-forms occur:

1. White, the upper whorls pale-pink or flesh-tinted; peristome yellowish; suture usually margined (fig. 1), 6 specimens. 1*a*. Similar, but having a brown streak behind the outer lip, 5 specimens.

2. White with two chestnut bands bordering a peripheral white belt, upper whorls fleshy, lip white or brownish (figs. 1*a*, *b*); 6 specimens.

2*a*. Similar but the peripheral belt and base tawny; a white umbilical patch or none (fig. 1*e*); 5 specimens.

3. Entire base purple-brown, a brown band above the peripheral white band; spire sometimes dark (fig. 1*d*); 9 specimens.

4. A white zone below the suture, elsewhere chestnut or purplish-brown, lip often brown (fig. 1*g*); 14 specimens.

5. Purplish-brown with fleshy suture and summit (fig. 1*i*); 2 specimens.

6. Base whitish, upper part purplish-brown (fig. 1*h*); one specimen.

7. Basal patch and peripheral band dark chestnut, a light chestnut zone above (fig. 1*c*).

A small lot from Waimea consists of forms figs. 1*d*, 1*g* and 1*i*).

In Waialee the color-form fig. 1*c* occurred, but only dead shells are in the lot taken by Gulick in the early Fifties, so it was probably extinct there at that time.

Across the range, near the head of Kaipapau (pl. 33, figs. 3 to 3*d*, coll. by Mr. Spalding), there is a colony having some patterns identical with Kawailoa *bulimoides*. The embryonic shell is usually dull purple; last whorl variously banded with dark chestnut and white, or yellowish-brown with or sometimes without bands; sutural border white or like the ground color. The lip is white or sometimes dark-edged; and in a large series taken, it is invariably dextral. This form has been called *vidua* by some collectors, but I believe erroneously. It is a slightly modified *bulimoides*, and not, I think, so closely related to the Bulimellas of Kaliuwaa as to those across the main range.

Mr. Gulick had this form from an adjacent locality. One dead shell labeled "Hauula," pl. 33, fig. 4, is now no. 92445, A. N. S. P.

9*a*. A. BULIMOIDES MISTURA Pilsbry & Cooke. Pl. 33, figs. 5-5*c*, 6-7.

In Kaliuwaa valley and the ridge eastward along the Castle trail, several colonies have been found by Messrs. Spalding, Thurston and others, which are not directly referable to *ovata, obliqua, oomorpha* or *spadicea*, while they belong to the same group of local races. The shell is either sinistral or dextral; an obesely ovate shape prevails; embryonic whorls are invariably colored, usually chestnut, darker than in *ovata* and *obliqua;* the lip-callus is rather narrow and the lip is narrowly chocolate-bordered outside and within. The color varies in different colonies, as follows:

Pl. 33, fig. 7, coll. by Spalding. On the edge of Punaluu valley, where the Castle trail passes over the crest into Kaliuwaa, a pure colony lives in a clump of ieie. The color is pale grayish blue-violet (Ridgway, pl. 35) varying towards lavender or pearl blue in different examples, suture bordered

with a white line or a band, another sometimes at the periphery. The spire is usually darker, becoming chestnut or light-brown at the summit. All but two of a large series in Mr. Spalding's collection are dextral. Length 20, diam. 12.1, aperture 10.2 mm.; 6 whorls.

Pl. 33, figs. 5 to 5*c*., coll. by Spalding. In Kaliuwaa valley, about three-fourths of a mile east from the following colony there is a patch of bananas upon which the shells vary from about the color of the preceding colony to ivory yellow or cream buff with or without two dusky bands; sometimes white above the upper band. The spire is usually bicolored, summit indian red or brown. Shells both sinistral and dextral, mainly dextral. Some specimens resemble *obliqua* and *oomorpha*.

Pl. 33, figs. 6, 6*a*, coll. by Spalding. At the bottom of Kaliuwaa, along the stream back of a cabin, there is a colony similar to the banded pattern of *ovata* except that the embryonic whorls are darker, usually dark vinaceous. This colony is mainly sinistral, but contains some dextral shells.

9*b*. A. BULIMOIDES SPADICEA Gulick. Pl. 33, figs. 13, 13*a*.

The shell is sinistral, glossy, embryo mars brown, blackish at the tip, becoming lighter on succeeding whorls, the last whorl pale or light orange-yellow above, below the periphery burnt sienna shading to chestnut downwards, and showing faint traces of two darker bands. *Sutural line white, extending to the apex.* Lip chestnut, bordered outside with the same; outer edge of the columella raised; columellar fold white or tinted. The later whorls show only the weakest traces of spiral sculpture.

Length 17.6, diam. 10.5, aperture 9 mm.; 6 whorls (type).

Length 17.5, diam. 11, aperture 8.5 mm.

Oahu: Kahana, on trees (Gulick, type loc.); Hakipuu (Gulick).

Achatinella spadicea GULICK, Ann. Lyc. N. H. of N. Y., vi, p. 247, Feb., 1858.—BALDWIN, Catalogue, p. 6 ("Hauula to Kahana").

"The white sutural band is continued up to the very tip

of the nuclear whorls in a manner quite different from what is seen in the bands of *A. obliqua* and other species of this group " (*Gulick*).

This small form is like *mistura* in having a dark summit, but differs by the white sutural line running to the apex and the color of the shell. I have been told that *spadicea* occurs below the falls in Kaliuwaa, but I suspect that the shells from there are *mistura*. *Spadicea* is known by very few specimens. There is one, the type, in coll. Boston Society of Natural History, described above and figured in pl. 33, fig. 13, and two from the Gulick collection in A. N. S. P., one of which is figured, pl. 33, fig. 13*a*. Also two shells from the same source in coll. Bishop Museum. I do not remember seeing specimens in other Hawaiian collections, and very likely the race is now extinct. It has resemblance to some dark forms of *A. rosea* in surface gloss and sutural border.

9*c*. A. BULIMOIDES OBLIQUA Gulick. Pl. 28, figs. 8 to 9*a*.

" Shell sinistral, subperforate, ovate, obliquely truncated at the base, solid, shining, striated; of ashy lead-color, with a broad white band beneath the suture. Apex obtuse, of a yellowish white color; spire convexly conical; whorls 6, subconvex, the last large. Columellar fold central, white, strong. Aperture oblique, truncately auriform, nearly white within. Peristome white, thickened within; with external margin somewhat reflected, arcuate; columellar margin forming an obtuse, sinuous ridge with a small umbilical cleft behind it; parietal margin thin. Length 23, diam. 13 mm. Average weight 9 grains " (*Gulick*).

Kahana, on trees (J. T. Gulick).

Achatinella obliqua GULICK, Ann. Lyc. N. H. of N. Y., vi, p. 245, pl. 8, f. 63, Feb., 1858; Evolution Racial and Habitudinal, p. 41, pl. 3, f. 16*h*-20*h*.—*Achatinella oomorpha* GULICK, Ann. Lyc., vi, p. 246, pl. 8, f. 64.

" Is allied to *A. ovata* Newc., with which it is associated geographically, but differs from it by its broader form and white lip. The dark coloring of the body-whorl abruptly terminates near the external margin of the peristome, leaving a

white border about an eighth of an inch in width around the outside of the lip, whereas in *A. bulimoides* and other allied species the color becomes darker on this portion of the shell though the lip itself be white. Dextral specimens are very rare. The color of the darker portion of the shell varies in different specimens from a dirty cream to slate color, but the ashy color given in the description is the most common " (*Gulick*).

The color of the darker, lower portion of the shell varies through several shades resembling purple-drab, vinaceous purple and slate-drab of Ridgway's *Color Standards*. These tints are produced by films of white laid over a brown layer, which may be exposed by scraping. The lip is white or nearly so typically, but in one lot it is fleshy-brown. The white border behind the lip mentioned by Gulick is by no means constantly present; often the dark color runs to the lip, which may have a narrow brown edge outside, but not so wide or dark as in *ovata*. The summit is usually light yellowish-brown; sutural margin well defined, bluish-white. Lip somewhat expanded, as in *A. ovata*, having a moderate callus within. The parietal callus is generally imperceptible. Between 3 and 4 per cent of the shells seen are dextral. Length 22, diam. 13 mm.; 6½ whorls.

Occasionally the dark color is restricted to a peripheral band, or it may disappear altogether, leaving the shell pure white. More often some brown remains on the spire. In a few shells the parietal callus is rather thick and brownish at the edge. The above notes are from the large series collected by Gulick.

A. b. obliqua was described from a colony in which the *sinistral* form very largely predominated. Mr. Gulick described shells from a colony in which the *dextral* form prevailed as *A. oomorpha*. While not exactly like typical *obliqua*, it does not seem sufficiently differentiated to require a name. The original account follows.

A. oomorpha Gulick. Pl. 28, figs. 10 to 10*c*. " Shell dextral, perforate, ovate, solid, shining, striated; ash or ash-brown with two obscure brown bands, white beneath the suture.

Apex rather obtuse, chestnut-brown; spire convexly conical; suture marginate, moderately impressed; whorls 6½, convex. Columellar fold central, white, strong. Aperture truncately auriform, white within; peristome thickened within, with external margin slightly reflected anteriorly, arcuate, white or brown; columellar margin reflected, detached, white; parietal margin very thin. Length 20⅓, breadth 11⅕ mm. Average weight 7 grains. Kahana, Oahu, on trees " (*Gulick*).

" Sinistral specimens are sometimes found which resemble *A. obliqua,* but are readily distinguished by the darker coloring around and upon the lip. I have from Hauula a few specimens which seem to belong to this species. Some of them are nearly white " (*Gulick*).

This dextral form of *obliqua* has the same peculiar colors, drab, dull-brown overlaid with lilac, etc., but also sometimes the chestnut-brown of *A. ovata.* It has another *ovata* character in the two-banded pattern of many shells of the typical colony. This pattern is not found in the typical colony of *A. obliqua,* judging by a lot of about 50 shells seen, though it occurs in a smaller brown-lipped lot in the Gulick collection. The form *oomorpha* often has exactly the coloration of typical *obliqua,* except that the lip is brown both externally and within. Pl. 28, fig. 10*a* is the typical *oomorpha* pattern according to Gulick's figured type, two-banded over a streaked ground. Shells also occur having the last whorl white. The length varies from 19 to 22.5 mm., but most specimens before me are smaller than *obliqua.*

9*d*. A. BULIMOIDES OVATA Newcomb. Pl. 28, figs. 1 to 1*d*, 2; pl. 29, figs. 2, 2*a*; pl. 33, fig. 2.

" Shell dextral, elongate-ovate, polished, finely striated longitudinally. Color light flesh-colored above, last two whorls white, obscurely banded with light-brown. Whorls 6, convex; suture slightly impressed, margined. Aperture subovate; columella twisted into a plait, slightly callus; lip slightly reflected, dark-brown. Length 0.9 inch. Breadth 0.45 inch. Variety *a*: shell white, bluish-white above, without coloring or bands. Habitat, Waiauai, Oahu " (*Newcomb,* May, 1853).

"Shell dextral or sinistral, elongately ovate; whorls 6, slightly margined above, rounded; suture moderately impressed. Aperture subovate, entirely margined with black; columella short, plicate, strong and twisted; lip thickened and slightly expanded. Color of shell pure white or yellowish-white, with or without obsolete brownish bands above. Length eighteen-twentieths, diam. ten-twentieths inch. Hab. Kahana, Koolan, Oahu" (*Newcomb*, 1854).

Oahu: Kahana (Newcomb); Kahana and Hakipuu (Gulick).

Achatinella ovata Newcomb, Ann. Lyc. N. H. of N. Y., vi, p. 22, May, 1853; P. Z. S., 1853, p. 130, pl. 22, f. 2, 2*a*, 1854.—Gulick, Evolution, Racial and Habitudinal, p. 41, pl. 3, f. 6*h*-15*h*.—*Achatinella candida* Pfr., P. Z. S., 1855, p. 2, pl. 30, f. 4; Monogr., iv, 519.—*Achatinella vidua* Pfr., P. Z. S., 1855, p. 3, pl. 30, f. 10; Monographia, iv, 522. *Cf.* Newcomb, Ann. Lyc. N. H. of N. Y., vi, p. 324.—*A. wheatleyi* Newcomb, Ann. Lyc., vi, pp. 147 (1855) and 324 (1858), not described (see under *A. elegans wheatleyana*).—*A. fricki* var. *d*, Pfr., Monogr., iv, 521; P. Z. S., 1855, pl. 30. f. 7*a*.

Dr. Newcomb included both white and banded forms in his description and figures, which are reproduced on pl. 29, figs. 2, 2*a*. They occur in the same hybrid colony in Kahana, pl. 28, figs. 1 to 1*d*; pl. 33, fig. 2. The surface is not very glossy, often rather distinctly striate. The apex is light colored, yellowish, pale-brown or white. The suture has no dark border below, and the impressed line defining the margin is usually rather weak, sometimes wanting. Outside the lip has a dark border behind, as in pl. 28, fig. 1*b*, though not always so fully developed. The lip is *distinctly expanded* outwardly and especially below, and has a chocolate edge, both outside and within. The internal callus is rather strong. In all color-forms at Kahana the shell may be either dextral or sinistral.

Length 23, diam. 13 mm.; 6½ whorls.

Length 22.5, diam. 13.5 mm.

Length 21.5, diam. 12 mm.

Length 18, diam. 11 mm.

Banded specimens would probably prove smaller than white

in the average. The following color-forms occur in a lot from Kahana, Gulick collection.

1. White, initial whorls often yellowish, lip chocolate (f. 1).

1*a*. Same, but whorls of spire with a dark band (fig. 1*a*).

1*b*. Brownish-cream color, spire as in 1*a* (fig. 1*b*).

2. White or whitish, with two chestnut bands separated by a peripheral white band; spire with a wide chestnut band above the suture (fig. 1*c*).

2*a*. Similar, but base entirely chestnut, usually lighter than the bands (fig. 1*d*).

Forms 1*a* and 1*b* are blends between 1 and 2.

In a lot of 49 specimens from Hakipuu, Gulick coll., all are dextral. Color-forms fig. 1 and no. 2*a*, chestnut streaked with darker, with a broad white band below the suture (pl. 28, fig. 2, Hakipuu) predominate, though there are some of the pattern of fig. 1*c*.

In another lot of 7 dextral shells in the Gulick collection from Kahana the lip is white, slightly yellowish at the edge. In three of them there are pale traces of brown banding, chiefly on the spire; the others being pure white throughout (pl. 28, fig. 7).

A. candida Pfr. is generally admitted to be merely the white form of *ovata*. The original figure is reproduced on pl. 30, fig. 4. The description follows. *Achatinella candida* Pfr. Shell dextral, imperforate, ovate-conic, solid, striatulate, a little glossy, pure white; spire convexly conic, the apex minute, black, rather acute; suture light, thread-margined. Whorls 6½, rather flat, the last three-sevenths to four-ninths the length, obsoletely angular, rounded at base. Aperture oblique, truncate-auriform; columellar fold moderate, superior, oblique, subcompressed; peristome brown-violaceous, strongly labiate within, the right margin expanded, columellar margin dilated, flat, thick, adnate. Length 22, diam. 11 mm., aperture 10½ x 5 mm. Sandwich Is., Frick (*Pfr.*).

It is likely that all the patterns of *A. fricki* Pfr., except pattern *a*, were based upon *ovata*. Pfeiffer's figs. 7*a*, 7*b*, reproduced in my pl. 30, figs. 7*a*, 7*b*, certainly look to me like *ovata*. I do not feel competent to pronounce upon fig. 7, which has

been taken as the type of *fricki,* as I have not seen the shell, and the figure is not closely matched among the specimens I have seen.

A. vidua Pfeiffer, of which the original figure is reproduced, pl. 30, fig. 10, is in my opinion merely a very small or stunted specimen of *ovata.* Dr. Newcomb, who examined the type in Mus. Cuming, decided it " to be a somewhat worn and faded specimen of this species " (*A. ovata*). The coloration is exactly that of some shells in Gulick's Kahana series, such as pl. 33, fig. 2, and pl. 28, fig. 1*d* out of the same lot. Adult shells in this lot of *ovata* range from 19.3 to 22.8 mm. long. I do not believe that *vidua* has any racial status. The description follows: " *A. vidua* Pfr. Shell dextral, subimperforate, conic-ovate, striatulate, under the lens most minutely decussate, glossy; deep brown, two-banded with white. Spire convexly-conic, the apex somewhat obtuse; suture nearly simple. Whorls 6, very slightly convex, the last a little shorter than the spire, rounded basally. Aperture a little oblique, truncate-oblong; columellar fold obsolete, slightly twisted. Peristome strongly labiate, the right margin narrowly reflexed, columellar margin dilated, subadnate. Length 18½, diam. 10 mm., aperture 9 mm. long, 4½ wide inside " (*Pfr.*).

The weakness of the columellar fold, noticed by both Pfeiffer and Sykes, can be paralleled in the large series of *ovata* before me. The smallest *ovata* I have seen is 17½ mm. long, dextral, with the pattern of pl. 28, fig. 1*c*.

9*e*. A. BULIMOIDES ROTUNDA Gulick. Pl. 28, figs. 3 to 6.

Very dark chestnut or chocolate, with a white or pale tawny zone around the upper part of the whorls; glossy; suture very distinctly marginate in the last 2½ whorls, dark-bordered above *and below*; apex dark at the tip. Whorls rather swollen, sinistral. Lip moderately thickened within, but less than in *A. ovata,* deep brown. Columellar margin generally less raised outwardly than in *ovata,* the columellar fold brown or white; parietal callus a very thin film.

Length 21, diam. 13 to 13.6 mm.; 6¼ whorls.

Kaaawa and Kahana (Gulick), on the dividing ridge.

Achatinella rotunda Gulick, Ann. Lyc. N. H. of N. Y., vi, p. 248, pl. 8, f. 67, Feb., 1858.

As it occurs on the Kaaawa valley side (figs. 3, 4), this form is so distinct that it might well be given specific rank. Some Kahana lots however, figs. 5, 5*a*, 6, show every pattern linking *rotunda* with *ovata*. Gulick remarks that "there is a variety with two black bands which resembles certain forms of *A. ovata* Newc., but is distinguished by its black suture, and its thinner and more regularly arcuate lip. Its bands are also deep black, while those of *A. ovata* are brown as in *A. bulimoides* Swains." Having before me several large lots from Kahana labeled *rotunda* by Gulick, I find that the subsutural dark border is as often absent as present, and the bands vary in shade, often being quite as light as in *ovata*. Most of this Kahana lot are more lengthened shells than the Kaaawa *rotunda*, but some, such as fig. 6, are typical in shape. These colonies are clearly *ovata* × *rotunda* hybrids.

A typical *rotunda* from the type locality, Kaaawa, is shown in pl. 28, fig. 3, Gulick coll.

9*f*. A. BULIMOIDES GLABRA Newcomb. Pl. 29, fig. 25; Pl. 33, figs. 8 to 11.

"Shell conically ovate, glossy; whorls 6, somewhat inflated, margined above; suture well marked. Aperture ovate; lip slightly subreflected, dark-brown edged with black, thickened within. Columella short, robust, expanded, and terminating in a twisted plait. Color bluish-slate, much lighter on the upper portion of the whorls; sometimes transversely banded with white or chestnut. Length nine-twentieths, width seventeen-twentieths of an inch" (*Newc.*).

Oahu: Kolaupoko (Newc.); Kawailoa and Waialee (Gulick); Waimea (Spalding).

Achatinella glabra Newc., P. Z. S., 1853, p. 139, pl. 22, f. 25; P. Z. S., 1854, p. 310.—Pfr., Monogr., iv, 520.—Thwing, Orig. Descript., p. 93, pl. 2, f. 2.—*B*[*ulimella*] *glabia* Newc., Hartmann, Proc. A. N. S. Phila., 1888, p. 29 ("Kawaiawa").

Newcomb's type figure (pl. 29, fig. 25) shows a shell with banded spire and light colored base. He subsequently (1854) stated that *A. glabra* is always dextral.

Some shells received from Newcomb are whitish, becoming streaked with purplish-drab on the last whorl, with a pair of brownish-drab bands at the periphery, lip with a dark-brown edge (pl. 33, fig. 9).

The specimens before me from Waialee (pl. 33, fig. 11), Waimea (pl. 33, figs. 8 to 8*c*) and Kawailoa (pl. 33, figs. 10, 10*a*) show a good deal of variation in color; all collected by Gulick.

1. Purple-brown, with a belt of light reddish-brown below the suture, upper whorls reddish or pale, lip fleshy-brown.

2. Base reddish-chestnut, upper third of the last whorl yellowish or white.

3. Base flesh-colored, upper part white, a dark band between, lip white.

4. Purplish-fleshy with indistinct whitish streaks, lip fleshy.

The preceding are Waimea shells, the same patterns occurring in Kawailoa. In Waialee I note an additional pattern.

5. Similar to no. 3, but whorls of the spire banded; lip brown. This is the typical pattern.

It will readily be seen that *glabra* intergrades in some of its color-forms with *bulimoides,* but both *glabra* and *bulimoides* have other color-forms special to each. The area of *glabra* overlaps that of *bulimoides* in part, and extends thence to the western end of the range.

Newcomb's type locality, "Koolaupoko," is an extensive district on the north side of that portion of the Main Range north and northeast of Honolulu (*koolau* signifying the windward or northern side, as *kona* the lee or southern district, on any of the islands). Later collectors have found nothing resembling *A. glabra* in the eastern part of the island; but Gulick, Spalding and others have taken the species in valleys of the northwestern end of the range. There can be no doubt that Newcomb was mislead as to the habitat of *A. glabra.*

Var. (?) *fricki* Pfeiffer. Pl. 30, fig. 7.

"Shell dextral or sinistral, subimperforate, oblong-ovate, solid, lightly striate, glossy, of very various colors; spire a little convexly-conic, the apex acute; suture narrowly marginate; whorls 6, a trifle convex, the last about equal to three-sevenths the total length, rotund at base. Aperture oblique,

reversed ear-shaped; columellar fold above, twisted, strong; peristome slightly expanded, obtuse, labiate and bordered with violaceous or black. Length 20-21, diam. 10½ mm.; aperture 10 mm. long, 5 wide.

"*a*. Isabelline, subfasciate with pale-brown, suture white.

"*b*. Bright chestnut, ornamented with darker and white bands, sinistral.

"*c*. Gray-brown, ornamented with darker bands, white above.

"*d*. White or buff, ornamented with two or three black-brown bands." (*Pfr.*)

Sandwich Islands, Frick in coll. Pfr.

Achatinella fricki Pfr., Proc. Zool. Soc. Lond., 1855, p. 3, pl. 30, f. 7, 7*a*, 7*b*; Malak. Bl., 1855, p. 5; Monographia, iv, 521. *Cf.* Sykes, Fauna Hawaiiensis, Mollusca, p. 307, under *A. glabra*.

A. fricki has not been recognized by Honolulu conchologists. Pfeiffer described and figured several varieties. His first figure (see pl. 30, fig. 7), which may be taken for his type, has been considered to be *A. glabra* Newc. by Mr. Sykes. I have not been able to match it at all closely among the *glabra* I have seen. It differs from *pulcherrima* by having a white sutural band. This band I have never seen in a dark *pulcherrima*, and I therefore give *fricki* temporary place as a variety of *glabra*, following Mr. Sykes.

Pfeiffer's color-form *b* and those following are probably different subspecies. His second figure (reproduced in pl. 30, fig. 7*a*) has been referred by Sykes to *A. ovata* Newc., I believe correctly, as it agrees fully with some of the old *ovata* received from Newcomb. Pfeiffer's var. *b* (see pl. 30, fig. 7*b*) is a sinistral shell, not exactly matched by any specimen I have seen, and probably not the same as typical *fricki*. The contiguous dark bands bordering a peripheral white band show it to belong to the *bulimoides* group, and it is quite possible that this figure also is an *ovata*.

10. A. elegans Newcomb. Pl. 28, figs. 12 to 13*d*; pl. 32, fig. 15.

"Shell conically-elongate, polished, shining, rather solid;

whorls 6, plano-convex, margined above; suture well impressed. Aperture subovate; lip white, expanded, subreflected, somewhat contracted in its center, thickened within; columella short, flat and lightly toothed. Color light and dark-brown alternating, longitudinally arranged in lineations or broad patches; sometimes with a white sutural band and an additional one on the body-whorl. Length eighteen-twentieths, diam. eight-twentieths inch." (*Newc.*)

Oahu: Hauula (Newcomb); Hauula, Kaliuwaa and Kahuku (Gulick); Hauula and Kaipapau (Baldwin).

Achatinella elegans NEWC., P. Z. S., 1853, p. 149, pl. 24, f. 57, 1854.

This species differs from all forms of *bulimoides* by its streaked coloration, a pattern not found in *bulimoides*. It is also more slender, in the average, but occasional specimens are as broad and compact as *bulimoides*.

It is said to be now extinct, having passed with the lower forests of the Hauula region, but it was an abundant shell in 1850-55, when Newcomb and Gulick were collecting. Besides the lots in these collections I have seen a beautiful series in the collection of Mr. J. S. Emerson.

Large series from Newcomb and Gulick, taken in Hauula, show considerable variation in the pattern. Usually the shell is *streaked in the direction of growth lines with brown* (walnut-brown to brownish-vinaceous of Ridgway's Color Standards), the shade variable, but usually appearing overlaid with white, sometimes dull chestnut-brown. The typical form as figured by Newcomb has the streaks cut by white bands at suture and periphery as in pl. 28, fig. 13*a*, but often one or both of these white bands is lacking. Newcomb's *description* applies to the form shown in pl. 28, fig. 12. Besides these prevalent patterns, there are a few additional white spirals in some shells, and sometimes the dark streaks are reduced or blurred. Rarely the streaks are confluent, the brown color almost evenly diffused. There are also a few pure white shells (fig. 13*c*). In a set collected by Dr. Newcomb I note rather indistinct dusky bands above and below the periphery, sometimes parted by a light-brown peripheral

band. The lip is sometimes white, more often fleshy-brown or darker. The white band below the suture sometimes runs to the very apex, as in *A. b. spadicea,* but oftener not. The early whorls are usually dull-brown. Dextral shells largely prevail, but all of the color-forms are common to both dextral and sinistral. In one lot from Hauula there are 82 dextral, 23 sinistral shells.

A set of 8 from Kahuku are very solid, coarsely streaked throughout, without bands (pl. 32, fig. 15, coll. by Gulick).

An unusual color-form, pl. 28, fig. 13*d*, has a pattern resembling some specimens of *oomorpha* or *obliqua* somewhat. The streaking of *elegans* is only weakly shown in places on the spire. The sutural white line runs to the apex, as in *spadicea* and some specimens of *elegans.* In its compact shape this shell is similar to several characteristically streaked *elegans* in the same Hauula lot. It is obviously an extreme form of *elegans.*

Color-variety *inelegans* n. var. Pl. 33, fig. 12. The shell is dextral, rather thin; glossy, rather distinctly striated spirally to the last whorl, which is smoother. Embryonic whorls corneous, following whorls cinnamon with white sutural border, last whorl pale cinnamon, shading to darker at the base, and having two orange-cinnamon bands, one above, the other below the periphery; sutural band pure white, beginning on the third whorl. Peristome a little expanded at base, very little thickened within, edged with dark-brown. Columellar fold weak, whitish. Length 19, diam. 10, aperture 9.5 mm.; 6 whorls.

Kaliuwaa, J. T. Gulick, no. 92504 A. N. S. P.

This shell was labeled *A. spadicea* by Mr. Gulick, but it is, in my opinion, a form of the *elegans* stock with less modified coloration than *elegans.* It does not seem closely related to the Bulimellas of upper Kaliuwaa, above the falls.

10*a*. A. ELEGANS WHEATLEYANA n. var. Pl. 28, figs. 11, 11*a*, 11*b*.

The shell is cinereous, blue-gray or slightly purplish, rarely purplish-brown, with faint whitish streaks and white or pale-

brown band above the periphery, sometimes bisected by a dark line; suture white-bordered; summit light yellowish. Aperture pale blue within, the lip thickened within, with a narrowly but distinctly expanded, acute brown edge. It is also narrowly bordered with brown outside. The strong columellar fold is white. Length 21, diam. 12 mm. or smaller, length 19.2, diam. 11 to 12 mm.

Punaluu (Gulick).

This race approaches *A. obliqua* somewhat, but seems nearer *elegans*. It has the maroon-brown or purplish-brown layer overlaid with a streaked white film, giving various tints difficult to name, but near dutch blue, deep madder blue and slate purple of Ridgway's Color Standards. The whitish or pale-brown band above the periphery is nearly always present, and often more conspicuous than in fig. 11*a*. Sometimes (fig. 11*a*) there is a thin yellow cuticle, but usually none. One lot of 8 from Newcomb, without habitat, consists of sinistral shells. Another lot from Gulick has 3 dextral shells in a total of 22. It is probably extinct now.

This form was named for Charles M. Wheatley, the well-known collector of Phoenixville, Pennsylvania.

"*A. wheatleyi*" was mentioned twice by Newcomb: in Annals of the Lyceum of Natural History of New York, vi, p. 147, October, 1855, where he says "*A. wheatleyi* Nob. is *A. vidua* Pfeiffer," and again in the same volume, p. 324, September, 1858, "The *A. vidua* Pfr., which I had supposed was my manuscript *A. wheatleyi*, I find in Mus. Cuming to be a somewhat worn and faded specimen of this species" [*A. ovata*]. As no characters were ever assigned to *A. wheatleyi* except by implication in the above remarks, we have no option but to accept Newcomb's published statement of what his *A. wheatleyi* was, even though he sent out specimens of what we are now calling *wheatleyana* as *A. wheatleyi*.

SERIES OF A. FUSCOBASIS.

Ovate shells, smaller than those of the *bulimoides* series; mainly sinistral, never marked with green, and having some resemblance to the *casta* series of *Achatinellastrum*. They are almost entirely shells of the high ridges and peaks.

11. A. FUSCOBASIS (E. A. Smith). Pl. 35, figs. 1 to 4.

Shell ovate, sinistral, glossy; white, the last whorl yellowish, ornamented with a median zone and base of brown. Whorls 6, a little convex, suture distinctly margined. Aperture white; peristome thick, brown, columellar fold strong. Length 16, diam. 10 mm. High up on Mt. Kaala on the Mokuleia side, on the island of Oahu, arboreal. (*Smith.*)

Oahu: Head of Kuliouou-Niu division ridge to Mt. Olympus, at the head of the Palolo-Manoa ridge (Spalding, Cooke, Kuhns and Wilder).

Bulimella fuscobasis SMITH, P. Z. S., 1873, p. 77, pl. 9, f. 15.—*Achatinella fuscobasis* Sm., THWING, Original Descriptions, etc., p. 83.—*Achatinella luteostoma* BALDWIN, Proc. Acad. Nat. Sci. Phila., 1895, p. 217, pl. 10, f. 7, 8 (Palolo to Niu).—*B. rosea,* a small white variety with a yellow lip, HARTMAN, Proc. A. N. S. Phila., 1888, p. 30, pl. 1, f. 4.

A. fuscobasis has the white ground of *A. tæniolata,* but it is invariably sinistral in a large number I have seen in various collections. It is also smaller, with the lip not so thick, the columellar margin less raised, and it has a different range of patterns. The reddish-brown color (mars orange, or burnt sienna, rarely chestnut or light orange-yellow of Ridgway's Color Standards) of the peripheral and basal bands, and the brown peristome are also characteristic of the typical form. The following color-forms occur in most colonies.

(*a*) Pure white with brown (liver-brown to dull-chestnut) peristome. Typical color-form of *A. luteostoma* (fig. 2).

(*b*) Peripheral band and basal patch brown, the space between them white or yellowish-brown. Typical color-form of *A. fuscobasis* (pl. 35, fig. 1, type-specimen).

(*c*) Same as *b,* but a basal band in place of the patch (fig. 3).

(*d*) Same as *b* or *c,* except that there is a light-brown band near the suture. In one shell from Mt. Olympus in the Spalding collection the upper and lower bands are broad, light-brown, the peripheral band narrow, darker.

(*e*) Whole base brown, dark or light (fig. 4).

Most of the specimens from Kuliouou (Spalding and

Thaanum collections), fig. 2, are pure white, but there are a few of the patterns of figs. 1 and 3.

Mr. Smith's figured type-specimen, no. 110 Gulick coll., Boston Soc. N. H., measures length 15.2, diam. 9.3 mm. It is shown in pl. 35, fig. 1. Other shells measure:

Length 16, diam. 9.2 mm.; 16 x 9.5 mm. (near top of Mt. Olympus; pl. 35, figs. 3, 4).

Length 17, diam. 10.5 mm.; 17.5 x 10 mm.; 16.2 x 9 mm. (Kuliouou).

The figured type of *A. luteostoma,* no. 65704 A. N. S. P., measures 16 x 9.7 mm., and one of Baldwin's examples 14.6 x 9 mm.

The several color-forms occur in the same colonies. I do not know that any of them has been found as a pure race.

A. luteostoma Baldwin was based upon the white form of *fuscobasis,* but Baldwin also included the banded shells in his original account, which follows. "Shell sinistral, imperforate, solid, ovate, spire convexly conical, apex obtuse; surface shining, marked with fine growth-lines, under a strong lens seen to be decussated by close, extremely minute spiral striæ, apical whorls smooth. Color white, with a reddish-yellow lip. Whorls 5½, margined above, slightly convex. Suture moderately impressed. Aperture oblique, sinuately oval, white within. Lip obtuse, thickened within, columellar margin very slightly reflexed, extremities united by a very thin yellowish callus. Columella reddish-yellow, terminating in a strong tortuous fold. Length 15½, diam. 9½ mm.

"In occasional examples the basal portion below the periphery is light-brown, and sometimes a bright chestnut spiral band encircles the periphery" (*Baldwin*).

The types of both *fuscobasis* and *luteostoma* were probably from somewhere in the head of Palolo valley. The locality "Mt. Kaala" given in the original description of *fuscobasis* was undoubtedly an error, as no such shell has been found in the Waianae range. A native boy probably brought the species to Gulick, who did not himself collect high in the mountains. The two original specimens of *fuscobasis* and the figured types of *luteostoma* are now before me.

A. fuscobasis is a species of the high ridge and peaks of the main range. Northeast of Mt. Olympus, on the ridge leading to Konahuanui, it passes into an undifferentiated form having the brown or brown-tinted lip of *fuscobasis* and the more capacious shape of *lyonsiana* (which also rarely shows some brown on the lip, in the type locality). An inspection of series in the collections of Messrs. Spalding, Thurston and Wilder convinces me that the Honolulu conchologists are right in regarding *lyonsiana* as a variety of *fuscobasis.*

11*a*. A. FUSCOBASIS LYONSIANA Baldwin. Pl. 35, figs. 5, 6, 7.

"Shell sinistral, imperforate, solid, ovate; spire convexly conical, apex obtuse; surface shining, striated with delicate growth-lines; apical whorls smooth. Color white, with two reddish-brown bands, one encircling the base, the other passing around the periphery and revolving on the spire just above the suture; the two bands are sometimes confluent, and often the shell is uniform white, without bands. Whorls 6, narrowly margined above, somewhat convex; suture moderately impressed. Aperture oblique, white within, sinuately oval; peristome white, rather obtuse, thickened within, basal and columellar margins slightly expanded, extremities united by a very thin callus; columella terminating in a strong, tortuous, white fold. Length 17, diam. 11½ mm.

"Animal: Mantle black, sometimes mottled with white, margined with a narrow line of lighter shade. Superior and under portion of foot light brown. Tentacles, tentacular sheath, and front above very dark brown" (*Baldwin*).

Oahu: Mt. Konahuanui, at about 3,000 ft. elevation (type loc.) to the top, spreading on the ridge southeastward, where it passes into *fuscobasis.*

Achatinella lyonsiana BALDWIN, Proc. A. N. S. P. Phila., 1895, p. 218, pl. 10, f. 9, 10, 11.—SUTER, t. c., p. 239, pl. 11, f. 52 (teeth).

A larger, more capacious shell than *A. fuscobasis*, with the lip and columella white. The patterns are:

(*a*) Pure white.

(*b*) White, with upper, peripheral and basal burnt sienna or chestnut bands, the upper usually weaker or sometimes wanting.

(*c*) A unique color-form in Mr. Spalding's collection (no. 2027) has the penultimate whorl deep chestnut, last whorl with two narrow dark bands (ii and iii). The ordinary brown-banded and white forms occurred in the same colony, which is about half a mile from the top of Konahuanui, in the main and typical locality.

The margin below the suture is invariably white, the surface is very glossy, and spiral lines are scarcely visible even on the early whorls; lip white, or rarely with a faint brown tint. It differs from *tæniolata* by being sinistral, with the outer border of the columellar lip decidedly less elevated.

Length 19.3, diam. 11.4 mm.

Length 18, diam. 12 mm.

Length 17.7, diam. 10.2 mm.

Dedicated to Prof. A. B. Lyons, formerly of Oahu College. Pl. 35, figs. 5, 7 are cotypes, 65693-4 A. N. S. P. Fig. 6, from the Irwin Spalding collection, taken half a mile from the top of Konahuanui, somewhat approaches the following subspecies.

11*b*. A. FUSCOBASIS WILDERI Pilsbry, n. subsp. Pl. 41, figs. 1-3*a*.

The shell is shaped as in *A. f. lyonsiana*. First two whorls buff-gray; last whorl having a chestnut or blackish-chestnut peripheral band and basal area, the latter split into bands in some colonies. Above the peripheral band there is a white band; below it a wider white or mars-yellow band. The rest of the upper surface is mars-yellow, mars-orange or burnt-sienna, usually excepting a sutural band or line of white. Lip and aperture fleshy in various tints, the lip narrowly thickened within. Columellar margin but slightly or not raised; parietal callus milky or transparent, very thin.

Length 17, diam. 10 mm.

Length 15.2, diam. 10 mm.

Summit of Lanihuli, at head of the Nuuanu-Kalihi ridge

(Irwin Spalding, W. D. Wilder). Also "Mauna Kope" a peak at head of the Kalihi-Moanalua ridge (Wilder).

This beautiful shell is the most ornate of the *fuscobasis* series. It is isolated from *lyonsiana* and *fuscobasis* by the deeply cut Nuuanu valley, which even at the pali is lower than any form of *fuscobasis* has been found. The Lanihuli colony is practically a pure race; the splitting of the basal patch into bands in one lot from Mr. Wilder, and the variation in the subsutural white border being fairly referable to "fluctuating variation." In the specimens taken by Spalding on the Koolau side of the peak the basal dark area is unsplit (fig. 2).

On the peak at the head of the Kalihi-Moanalua ridge there are shells with the typical pattern, a few with darker peripheral and basal bands on a tawny ground (pl. 40, figs. 3, 3*a*) and others with a tawny ground and blackish-chestnut base (*A. castanea* pattern), the subsutural border white. Both of these are rare mutations.

12. A. PUPUKANIOE Pilsbry & Cooke, n. sp. Pl. 35, figs. 14 to 17.

The shell is dextral, conic, the greatest diameter near the base, solid, brilliantly glossy; uniform white, ivory yellow with white sutural line, or either of these tints with a burnt sienna band immediately above, a wider and darker one below the periphery. Suture margined but without a dark line. Spire white. Lip not expanded, the edge brownish, internal rib white, or sometimes the whole lip is pale-pink. Columellar fold rather strong and abrupt, white.

Length 16.3, diam. 9.7, aperture 7.8 mm.; 6 whorls.

Length 16, diam. 9.2, aperture 8 mm.

Oahu: Crest of the Waimano-Manana ridge, 1 to 1½ miles from its junction with the main range. Types 108068 A. N. S. P., Pilsbry, 17-II-1913; also head of Waiawa valley, Irwin Spalding.

This species, which I collected in company with Messrs. Spalding and Merriam, has a great resemblance to *A. fuscobasis*; but that is invariably sinistral, and separated from the

habitat of *A. pupukanioe* by about a fourth of the length of the island, wherein no similar form has been found. It also resembles *A. s. dextroversa,* of the northwestern end of the range. *A. casta,* in some Waimano lots, resembles *pupukanioe* in coloration, but is more lengthened and sinistral. The resemblance is so close, however, that I would refer the new form to *casta* as a variety, were it not that old specimens (such as pl. 35, fig. 15) have the columellar lip built up to form a ledge, exactly as in *Bulimella,* and unlike any of the very long series of *casta* I have seen.

The apical whorls are rather deeply eroded in all of the adult shells from the type locality. In a young one they are cartridge-buff with a white band above the suture.

In Mr. W. D. Wilder's collection a series from the type locality contains several aberrant individuals: streaked with burnt-sienna on a yellow ground, and others with the same pattern interrupted by broad white zones at suture, periphery and base.

A long series of smaller specimens was taken by Mr. Spalding in a very limited area on the southern slope of the peak at the northern head of Waiawa valley. White shells are in the majority, but some have a basal band (iii), and in one before me there are two faint bands (ii and iii), and the eroded embryonic whorls are brown. Two measure:

Length 14.3, diam. 8 mm.

Length 16, diam. 8, aperture 7.7 mm.

13. A. SOWERBYANA Pfeiffer. Pl. 30, figs. 14, 14*a*; pl. 34, figs. 9, 10.

Shell sinistral, imperforate, conic-oblong, rather solid, smoothish, having a gummy gloss; tawny buff, slightly streaked with a deeper shade. Spire a little convexly-conic, the apex subacute, suture margined. Whorls 6, very slightly convex, the last a little shorter than the spire, rounded sack-like at the base. Aperture oblique, inversely ear-shaped, white within; columellar fold superior, strong, twisted, roseate; peristome rose-lipped, the outer margin shortly expanded, columellar margin dilated, adnate. Length 18, diam. 9 mm.;

aperture 8 mm. long, 4 wide. Sandwich Is., Frick. (*Pfr.*)

Oahu: Punaluu to Kaipapau; various varieties as far northwest as Kahuku and Pupukea.

Achatinella sowerbyana Pfr., P. Z. S. 1855, p. 4, pl. 30, f. 14; Malak. Bl., 1855, p. 65; Monogr., iv, 527.—Baldwin, Catalogue, p. 6 (Kalihi?).—*Bulimella sowerbiana* Pfr., Hartman, Proc. A. N. S. Phila., 1888, p. 31.

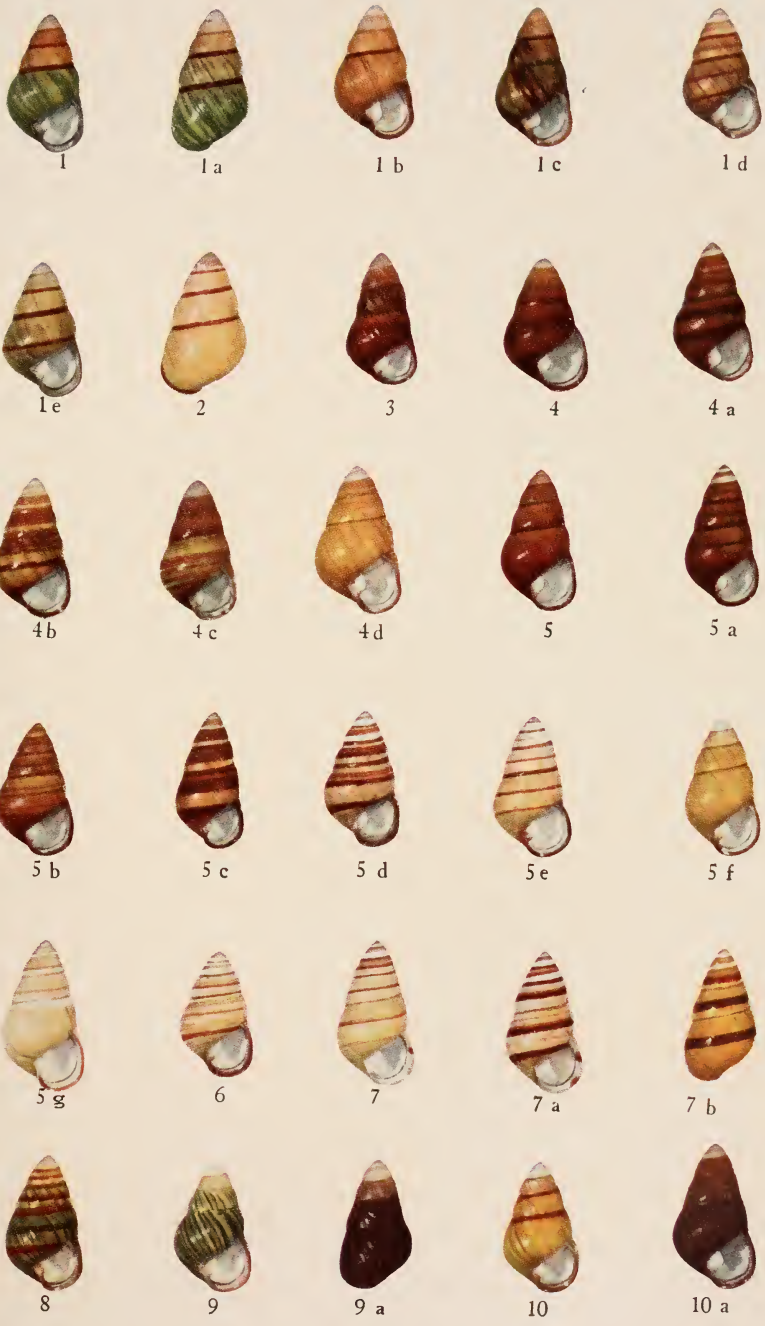
Achatinella oviformis Newcomb, Pfr., P. Z. S., 1855, p. 208; Monogr., iv, 540.—Newcomb, Ann. Lyc. N. H. of N. Y., vi, p. 147 (as a synonym of *A. sowerbyana* Pfr.).—Sykes, Fauna Hawaiiensis, p. 309.—*A. multicolor* Pfr., in part, P. Z. S., 1855, pl. 30, f. 11*a*; *cf.* Sykes, Fauna Hawaiiensis, Mollusca, p. 309.

Pfeiffer described var. *b* as "a little smaller, yellow-whitish, the base chestnut or greenish." His fig. 14*a* represents this color-form, and is reproduced in pl. 30, fig. 14*a*.

A. sowerbyana is a handsome shell, very little known before the last few years, but now familiar by the splendid series in the collections of Hon. L. A. Thurston and Irwin Spalding. It is invariably sinistral, typically wax yellow or sulphine yellow, fading upwards, with the sutural margin brown, summit usually pale or white. The surface has the gloss of varnish, and the lip and columella are of a luscious pink tint which has given it the local name of "watermelon shell." It is smaller and more slender than other smooth Bulimellas of the region. The lip-rib is narrow. It is no doubt related to *A. fuscobasis*, of the eastern end of the range, but I agree with all the island conchologists in holding the two distinct. Like *fuscobasis*, it lives mainly on the heights.

Frick, who supplied Pfeiffer's type, gave no locality, but it seems likely that he got the species in some valley of the Kaipapau-Kaliuwaa region where it reached a lower level than usual, and thus came within the zone accessible to the early collectors.

Plate 30, fig. 14 is reproduced from Pfeiffer's type figure. Pl. 34, fig. 9, from the bottom of the central ravines of Kaipapau, and fig. 10, Kaliuwaa, near the Castle trail, are probably from as near where Frick took the original lot as a mod-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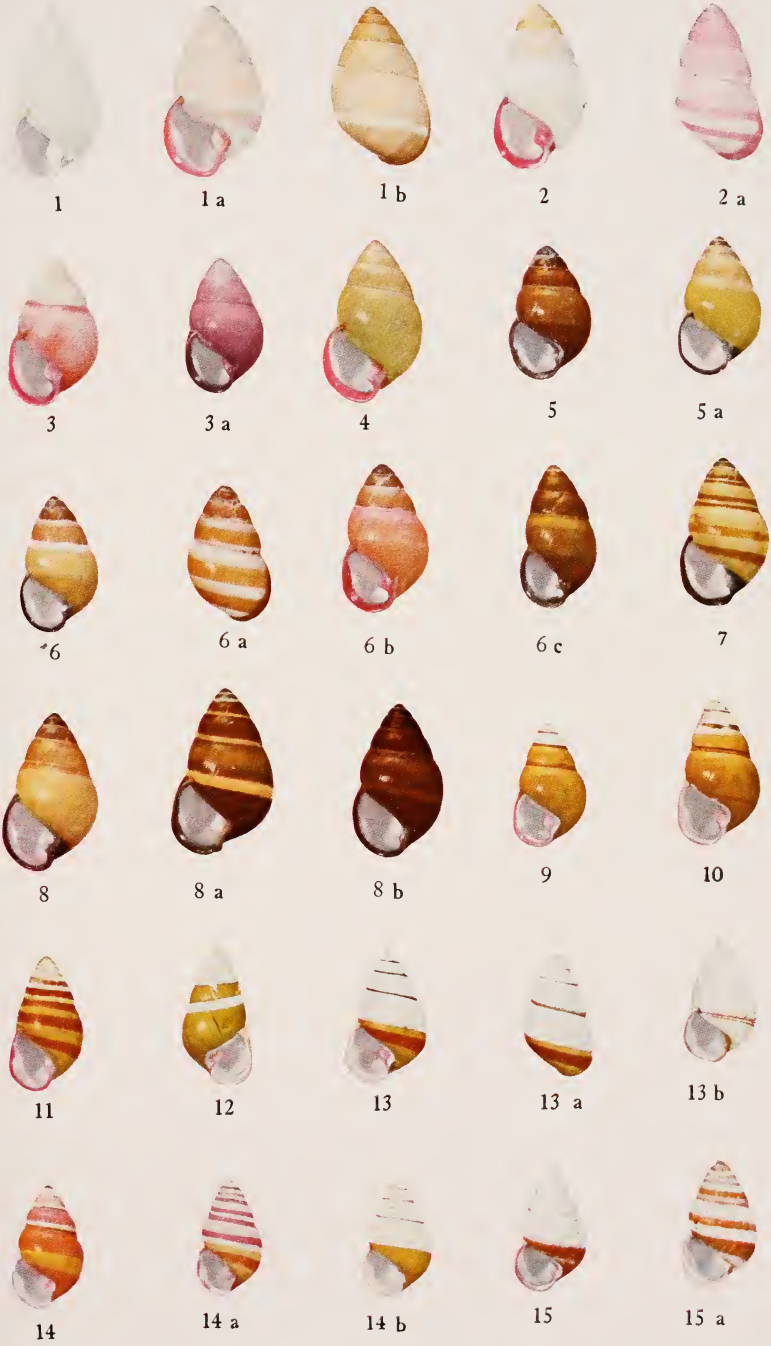
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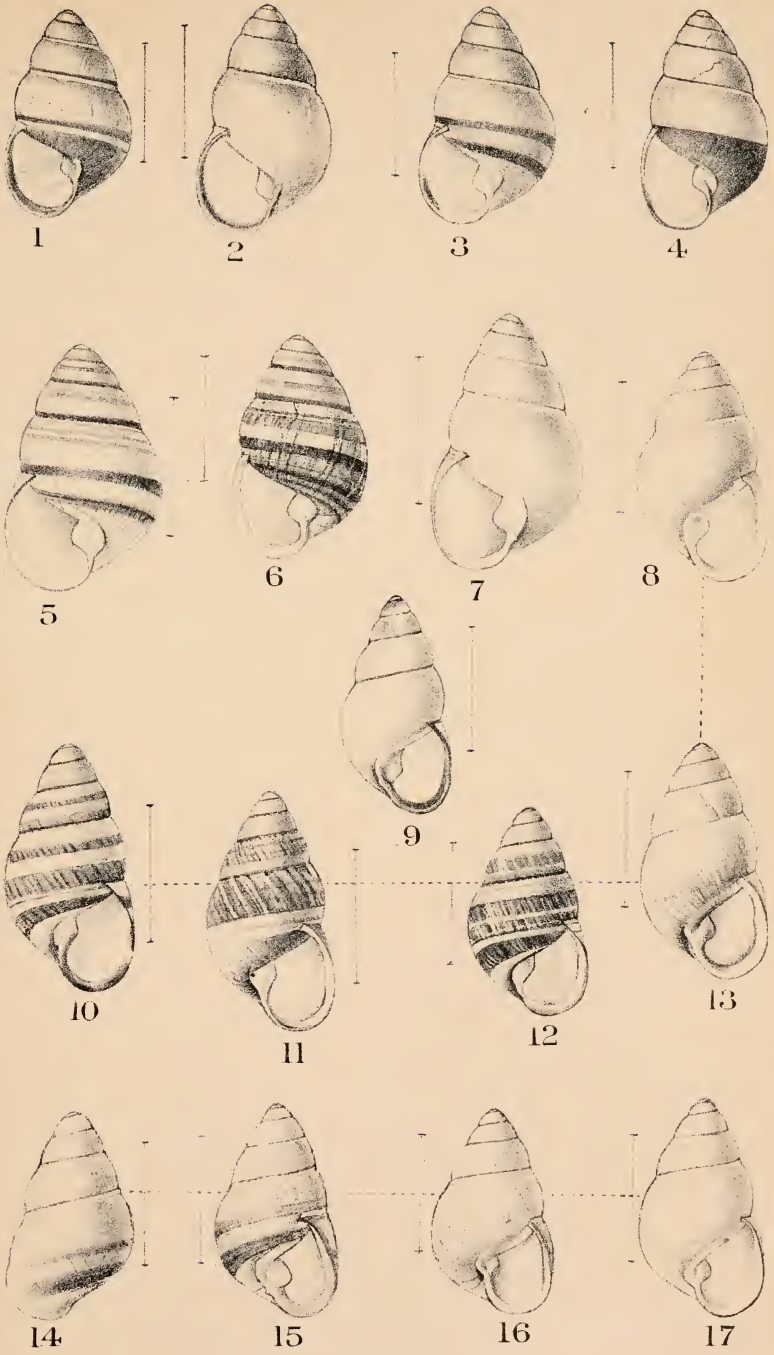
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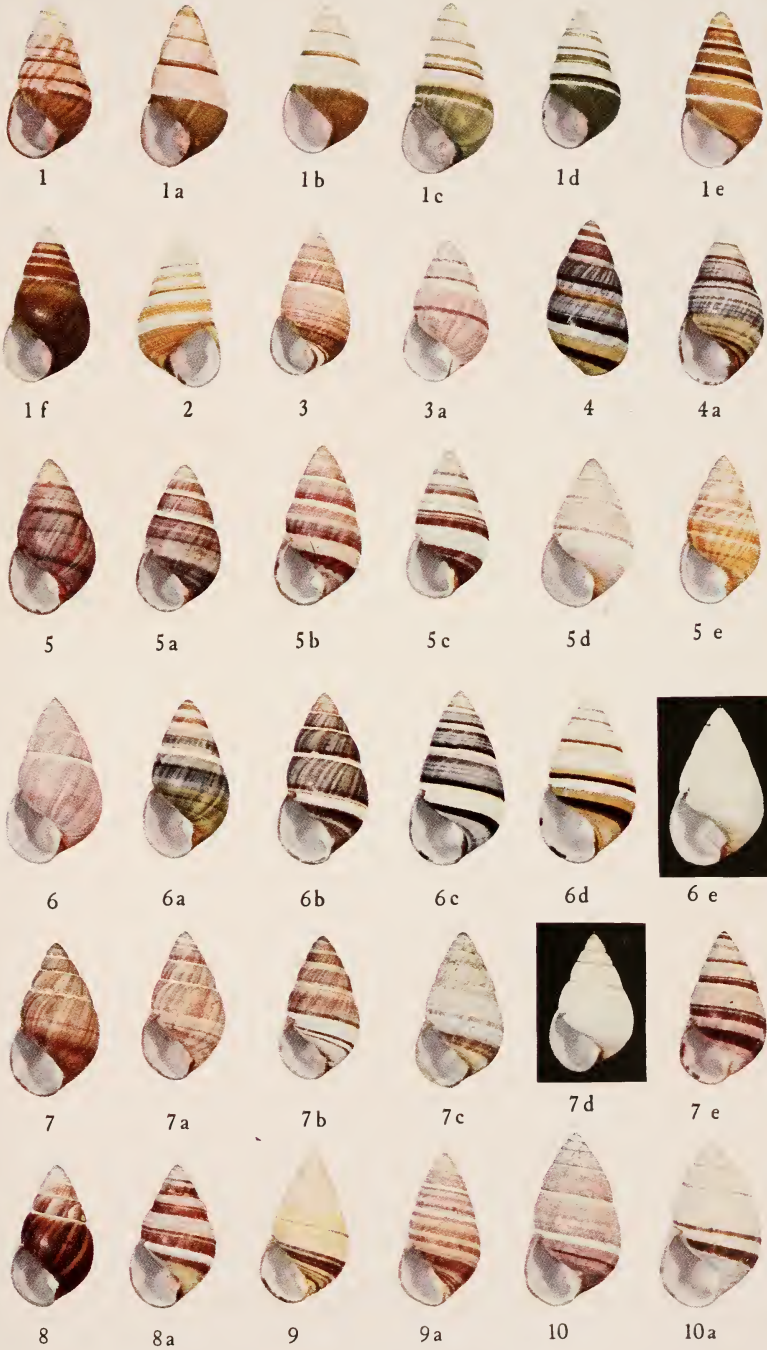
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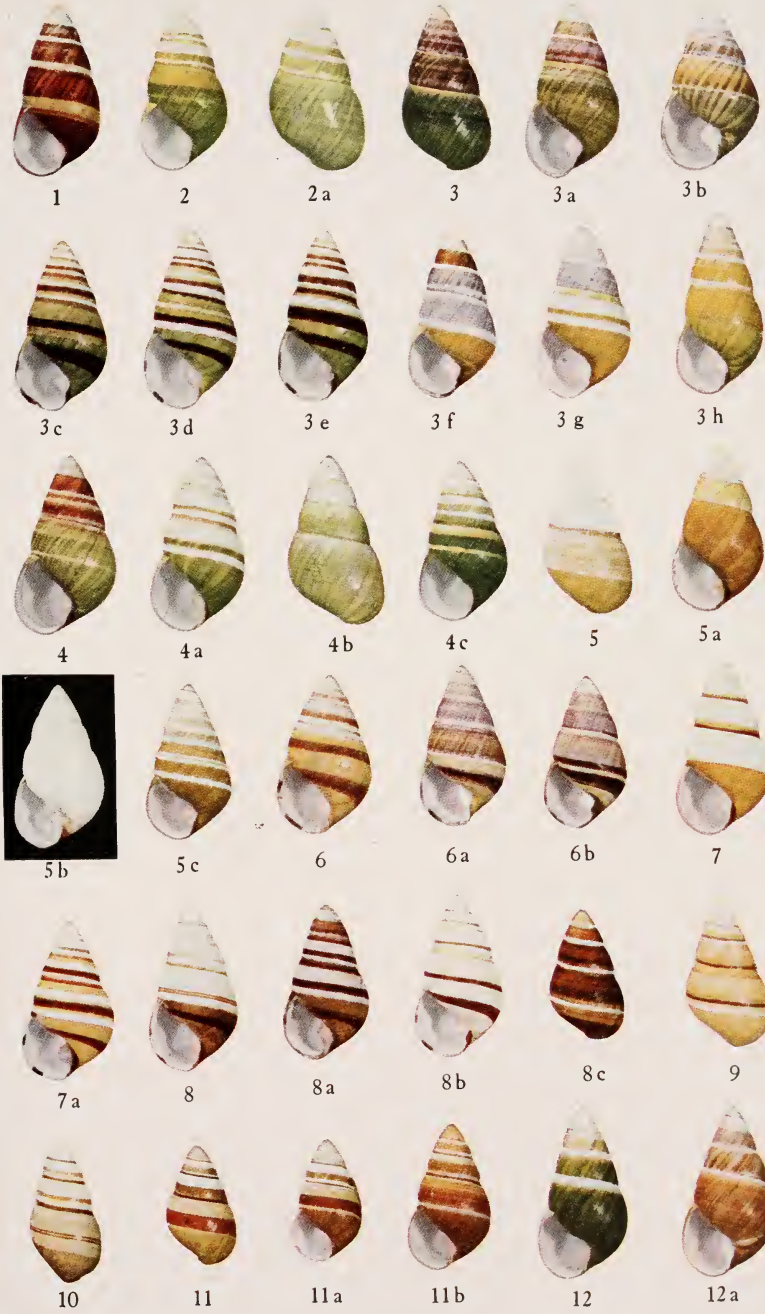
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ern collector will ever get. The shells are either plain except for the sutural band (pl. 34, fig. 9, Kaipapau), or have a band around the base, as in pl. 34, fig. 10 from Kaliuwaa valley near the Castle trail. This shell measures, length 19.2, diam. 10, aperture 9 mm.; 6⅓ whorls.

In one lot from the Kaipapau end of the Castle trail, no. 1866 Spalding coll., there are 20 of the plain typical form with a sutural band only, 3 with a basal band. There is also one chestnut specimen with a light sutural band. It has also been taken by Mr. Thurston in the banana patch in Kaipapau along the Castle trail towards Punaluu.

Color-form *oviformis* ' Nc.' Pfr. Pl. 34, fig. 11; pl. 30, fig. 11*a*. " Shell sinistral, imperforate, ovate-conic, solid, striatulate, white under a glossy olivaceous epidermis, one to three banded with brown. Spire convexly-conic, the apex rather acute, white. Suture deeply margined. Whorls 5, scarcely convex, the last about three-sevenths the total length. Aperture nearly diagonal, ear-shaped; columellar fold moderate, tooth-like, reddish; peristome unexpanded, the margins joined by a thin callus, the outer margin labiate within; columellar margin dilated, adnate. Length 17, diam. 8⅔, aperture 7⅔ mm. long, 4 wide. Oahu, Newcomb " (*Pfr.*). Type in Pfeiffer's collection.

Mr. Sykes has referred Pfeiffer's sinistral form of *A. multicolor* to *oviformis,* no doubt correctly. Pfeiffer's figure is reproduced in pl. 30, fig. 11*a*. Specimens from Kaliuwaa are three-banded with brown (" Hay's russet ") on a wax-yellow ground, pl. 34, fig. 11, coll. by Spalding. It seems to be merely a color-form or mutation of typical *sowerbyana,* hardly worthy of a name.

13*a*. A. SOWERBYANA THURSTONI P. & C., n. subsp. Pl. 34, figs. 13 to 14*b*.

The shell is invariably sinistral; ground-color *wax-yellow below the periphery, white above it,* with a band of burnt-sienna below the periphery. Sutural margin defined by a deep line, usually with an inconspicuous, scarcely noticeable, dark line next the suture. Apex generally tipped minutely

with dull purple. Lip-rib narrow and whitish or very pale. Columellar fold moderate, pink.

Length 17.2, diam. 10.5, aperture 8.5 mm.; whorls 5½.

Length 16, diam. 9.5, aperture 8 mm.; whorls 5½.

Length 16, diam. 8.7 mm.

Kahuku, 1,500-1,700 ft. elevation, L. A. Thurston, cotypes in coll. A. N. S. and Bishop Mus. Also in Thurston collection. Waimea, overlooking Laie, Irwin Spalding.

Rarely the pigment is deficient, ground white throughout and the band reduced to a group of pale-brown lines (fig. 13*b*). This decolored form approaches *A. s. laiensis*. There may also rarely be traces of faint spiral lines near the lip on the upper surface. These lines are yellowish with several pink ones near the peripheral white band. These colors are so delicate that they can hardly be seen without a lens, and are mentioned here chiefly because this pattern reminds one of *A. casta*. The fact is, *A. s. thurstoni* stands on the borderline between *Bulimella* and the *casta* group. Looking at some individuals one is disposed to rank it as a variety of *sowerbyana*, while others have features which certainly come as near to *casta*. Figs. 13 to 13*b* are cotypes from Kahuku.

Further southeast on the main range, upon the Waimea-Laie ridge, Mr. Spalding found a lovely color-form, illustrated in pl. 34, figs. 14, 14*a*, 14*b*. As in the typical color-pattern, the ground-color is wax-yellow below the periphery, white above it (when not covered by another color); either bandless or with four peach-red, coral-red or geranium-pink bands: sutural, supra- and infra-peripheral and columellar; or bands i and ii may be concrescent into a broad zone, as in fig. 14; lip-rib narrow, whitish or with spots at the ends of the bands; apex dusky purplish or nearly white. Length 15 to 16 mm.

13*b*. A. SOWERBYANA LAIENSIS Pilsbry & Cooke, n. subsp. Pl. 34, figs. 15, 15*a*.

The shell is sinistral, ovate-conic, moderately solid; *white, with several brown bands,* from burnt-sienna to chestnut in color; the one below the periphery is widest and most con-

stant, one above the periphery is usually present, with sometimes a sutural line and columellar patch also; rarely the shell is pure white. The apex is whitish or tinged with dull purple. Surface has a moderate gloss, and is weakly striate under the lens. Suture distinctly margined. The aperture is not very oblique, white within; lip a trifle expanded at the edge, having a rather narrow whitish callus rim within, dull purplish-brown towards the edge in well-banded individuals. Columellar fold white, or often in part brownish.

Length 17, diam. 9.7, aperture 8.3 mm.; 5½ whorls.

Length 16, diam. 9.5, aperture 7.4 mm.

Oahu: Laie, division ridge above the Castle cut trail, Irwin Spalding. Cotypes in A. N. S. and Bishop Mus. Also in Spalding coll.

This subspecies does not have the greenish-yellow cuticle or brilliant gloss of *A. sowerbyana*. The bands are vertically streaked with chestnut on a lighter, more yellow tint, the contrast more obvious in some specimens than in others. Whether it will eventually prove separable from *A. s. thurstoni* cannot now be decided. Its locality is rather remote from the area of *A. casta*, some of the Waimano patterns of which certainly resemble *laiensis*.

There are a few white, bandless specimens in Mr. Spalding's lot from the type locality, no. 3556 of his collection, and one shell with yellow base and wide subperipheral blackish band (band iii), establishing a connection with var. *thurstoni*.

13*c*. A. SOWERBYANA DEXTROVERSA P. & C., n. subsp. Pl. 35, figs. 8 to 13.

Shell *dextral,* white, sometimes uniform, but typically encircled by several bands, which are light-brown, vertically streaked with chestnut; a narrow chestnut columellar area; suture margined with a dark line which ascends to the apex, in banded individuals. Peristome narrowly thickened within, pale with dark spots at the ends of the bands. Columellar fold moderate, white or nearly so. Length 18.5, diam. 9.5, aperture 9 mm.; 5¾ whorls.

Pupukea, D. Thaanum. Cotypes in A. N. S. P. and Bishop Museum. Also in Thaanum coll.

This is the western terminal member of the *sowerbyana* series. In a considerable lot seen it is always dextral. Except in direction of coil and some details of banding it has a close resemblance to *laiensis*. Some of the white shells have the lip white, others having it purple-brown.

Further up, on the Kahuku division ridge, the same subspecies has been taken by Mr. Spalding, 3558 of his collection, 108129 A. N. S. P. The shells are pure white, or light brown with dark sutural line and bands ii, iii, and the columellar region are narrowly dark; band ii being narrow, iii wide and darker.

This subspecies is quite unlike *A. s. roseoplica* except that both are dextral.

13*d*. A. SOWERBYANA ROSEOPLICA P. & C., n. subsp. Pl. 34, fig. 12.

The shell is *dextral,* oblong-conic, rather solid, white under a greenish-yellow (sulphine-yellow) cuticle which is slightly streaked and is *deciduous in a band below the suture* and on the spire; apex white or pale-brown. Whorls but slightly convex. Lip-rib narrow, white or pale pink, the columellar fold roseate.

Length 18, diam. 9, aperture 8.2 mm.; 6 whorls (A. N. S.).

Length 17.2, diam. 8.7, aperture 7.8 mm. (Bishop Mus.)

Opaeula, above forest-fence line, type loc.; also on the northeastern division ridge between Opaeula and Kawaihalona, Irwin Spalding.

A few of the specimens from the last locality have a pinkish-brown line bordering the suture on the last whorl. All of the specimens from both colonies are dextral. It is widely separated from all other known colonies of *sowerbyana*.

Section ACHATINELLASTRUM Pfeiffer.

Achatinellastrum PFR., Malakozoologische Blätter i, 1854, p. 133.—PEASE, P. Z. S. 1869, p. 646 (restricted to "species allied to *A. productum* Reeve").—SYKES, Fauna Hawaiiensis, p. 320, 1900.

The shell is imperforate, ovate-conic or oblong-conic,

smooth, with unexpanded lip, which is but slightly or not thickened within; columellar margin not raised or thickened on the face.

Type, *A. producta* Reeve. Distribution, Oahu, chiefly on the Main Range.

This is the most generally distributed group of *Achatinella*. In many places it is found on the northern side of the main range, and in a doubtless more humid time of the Pleistocene it lived down nearly to sea level. In the Waianae range there are a number of colonies, but all excessively small, and situated on the inland slope.

Achatinellastrum is related to *Bulimella* through such species as *casta* and *sowerbyana,* where the sectional borders are debatable. Such forms seem to be the least changed descendants of the ancestral common stock. No point of contact with the section *Achatinella* (*Apex*) is traceable among the recent species.

Achatinellastrum is more prolific in color-mutations than any other group of the family. The number of patterns runs into hundreds. About 72 names have been applied to supposed species. This number was reduced to 49 by Mr. Baldwin in his Catalogue of 1893. Mr. Sykes, 1900, recognized 35 species and 3 varieties. In the following account 17 species and 14 subspecies are admitted, two species and three subspecies being new.

In the section *Achatinellastrum,* it is not likely that any conservative zoologist having adequate collections and data, would recognize more than seventeen species; but if the evidence is critically examined, it appears that there are phenotypically intermediate forms—hybrids or undifferentiated remnants of the parent stock—between many of the conventional species. It would be quite possible to reduce the "good species" to nine or ten.

Thus, in the eastern end of the Main Range, we have a chain of connected forms in (1) *A. phœozona—fulgens—stewartii—vulpina.* A little apart from them stands (2) *A. buddii.* This is succeeded by the form-chain of (3) *A. bellula —casta—juncea.* Allied, but not connected are (4) *A. juddii*

and (5) *A. papyracea.* Westward we find the connected series (6) *A. livida—curta—dimorpha,* with a distinct satellite species, (7) *A. cæsia.* The Waianae species are as yet but little known, and apparently are distinct.

Much remains to be done in the definition of the critical points where one polymorphic population gives place to another, especially in the western half of the Main Range. It is quite likely that further collections and study will modify our present specific boundaries, or perhaps abolish some of them.

I have not constructed a key to the forms of this group for the reason that most species of *Achatinellastrum* vary widely in color. Such small differences in size and shape as there may be in the average between allied species, are usually covered by individual variation. I fear that any key I could make would surely mislead anyone who attempted to name single specimens by it. The expert will naturally turn to the group or "series" to which his unnamed shell belongs. Those without special knowledge of *Achatinella* will doubtless most easily get from the plates a clue to what they seek.

Series of Achatinellastrum.

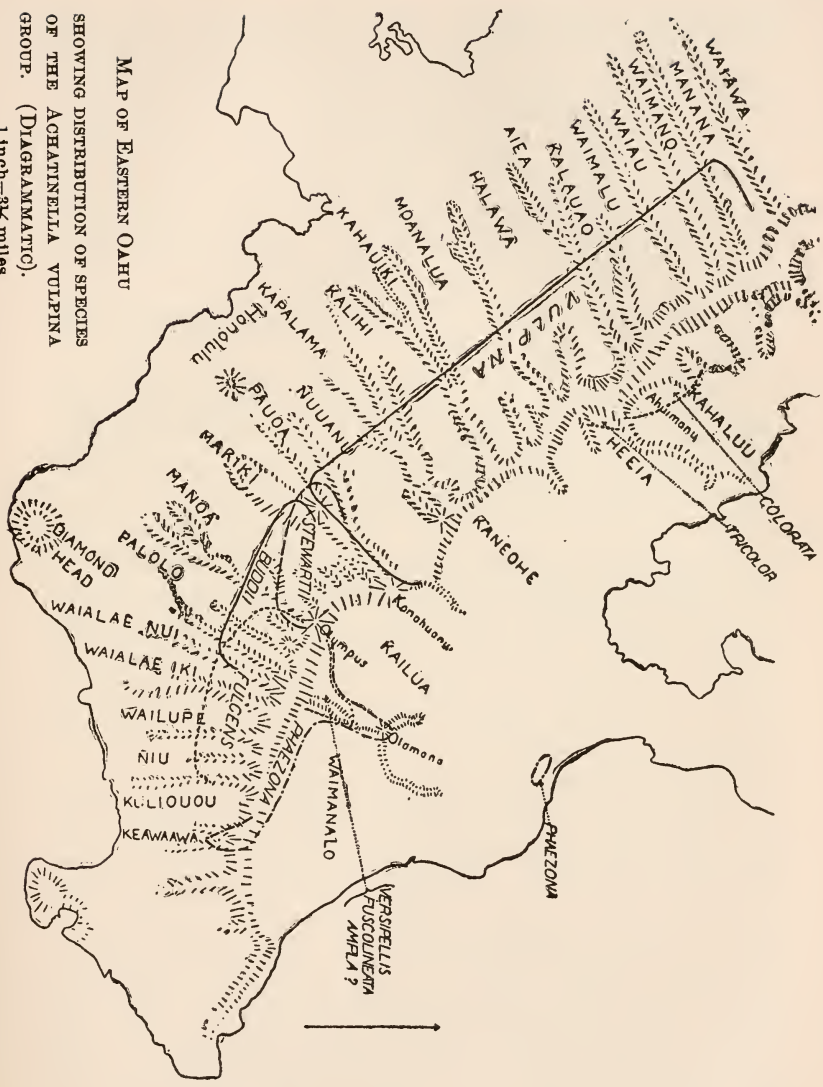
Series of A. vulpina. Eastern end of the Main range, west to Manana. Mainly rather large and moderately strong shells, conspicuously colored, green, yellow or chestnut, generally streaked or banded, rarely white. Species no. 14 to 18.

Series of A. casta. Tantalus to Helemano. Smaller shells, whitish, yellow or chestnut, usually with bands. Species no. 19 to 21.

Series of A. papyracea. Middle of Main range. Rather capacious, ovate, *thin shells,* the embryonic whorls not marked with an ocher band. Species no. 22.

Waianae Range species, intermediate between the *papyracea* and *livida* series. Species no. 28 to 30.

Series of A. livida. Western half of the Main Range. Rather small, stout, ovate or short shells, dull green, yellow or white, often with a few bands, or sometimes streaked; embryo often with an ocher band. Species no. 23 to 27.



MAP OF EASTERN OAHU

SHOWING DISTRIBUTION OF SPECIES OF THE ACHATINELLA VULPINA GROUP. (DIAGRAMMATIC).

1 inch=3¼ miles.

Series of A. vulpina.

Large, highly colored forms, usually chestnut, yellow or green, and variegated with streaks or bands; inhabiting ridges

and ravines from Manana valley to the eastern end of the Main Range. No other group of *Achatinellastrum* is found east of Manoa valley, but westward the *casta* group appears in the area inhabited by *vulpina* forms.

The distribution is diagrammatically indicated in the accompanying map, p. 183. The stations of the respective species are included between the looped lines and the main axis of the range, but in reality the colonies actually occupy only a small fraction of the areas indicated.

14. A. PHÆOZONA Gulick. Pl. 24, figs. 10 to 13; pl. 36, figs. 10, 10*a*; pl. 43, figs. 1 to 1*d*.

"Shell sinistral, scarcely perforate, oblong-ovate, solid, shining, striated; white with from one to six black or chestnut bands varying in width; apex subacute; spire convexly conical; suture marginate, moderately impressed; whorls 7, moderately convex; columellar fold central, white, strong; aperture a little oblique, lunately rounded; peristome acute, well thickened within, with columellar margin dilated, adnate, or sometimes slightly detached; parietal margin wanting. Length 22, diam. 12⅔ mm.; length of body whorl 16¼ mm.; length of aperture 11 mm.; an average sized specimen. Length of a large specimen 25.4 mm. Average weight 10.5 grains." (*Gulick.*)

Mr. Gulick enumerates the following color-variants. "*Var. a.*—With one broad band encircling the base. *Var. b.*—With two dark bands, one entering the aperture, the other revolving above the suture. This and var. *a* are sometimes found in Kailua, Oahu. *Var. c.*—White, with 3 or 4 bands at the base. *Var. d.*—Without bands, but more or less streaked with fawn brown. *Var. e.*—Dark brown, with two white bands, one sutural, the other on the periphery of the body-whorl. *Var. f.*—Brown, with one or more black bands. *Var. g.*—Ash or olive brown, with one or more light bands. *Var. h.*—Chestnut or olive brown, with fine, black, spiral lines."

Oahu: Keawaawa, on kukui and ki (Gulick, Spalding). Formerly on the northern side of the range in Waimanalo, Kailua and Olomana (Gulick); fossil in a coconut plantation

about half a mile from the shore, southeast of Kailua Bay, in humus of plowed fields (Spalding).

Achatinella phaeozona Gulick, Ann. Lyc. N. H. of N. Y., vi, p. 214, pl. 7, f. 40, December, 1856.

"May be grouped with *A. buddii* and *A. fulgens* Newc., but differs in its more solid structure, its thicker lip and columellar fold, and in the more convex outline of its spire. It also lacks the black tip which characterizes *A. buddii.* The typical varieties found in Keawaawa are rare, that sterile region affording but few trees, which occupy the ravines near the summit of the ridge." (*Gulick.*)

Professor Hyatt looked upon *A. phæozona* as the common ancestor of *Achatinellastrum, Bulimella* and *Apex* (*Science,* viii, p. 395). Later he claimed for *A. phæozona* a relationship to *Kauaia.* Our investigations lead to totally different results, and we believe the affinities claimed by Hyatt to be altogether erroneous.

Some specimens of *phæozona* are hardly separable from certain shells of the *plumata* pattern of *A. fulgens*; but other patterns of both differ widely. *A. phæozona* never has green or yellow varieties.

Although this species is at present restricted to a very small area, it formerly inhabited an extensive district on the northern or Koolaupoko side of the island, which was then wooded down to the shore. About sixty years ago, when Mr. Gulick discovered the species, it was still to be found in a few scattered colonies in Waimanalo and Kailua. On his labels Mr. Gulick indicated that it was almost extinct in these valleys.

The Keawaawa lot in Gulick's collection consists wholly of dead shells. A series is shown in plate 24, figs. 10-13, pl. 36, f. 10, 10*a*. The shell is commonly white with chestnut bands 0230 or 0030, but the bands vary in width, sometimes nearly covering the last whorl. There is almost always a white band at the periphery, and the sutural margin and summit are always white. Often the bands are split, giving rise to numerous band-forms, mentioned by Gulick.

Another pattern is closely streaked with fleshy-brown, cut

into bands by white spiral lines and zones, and often with darker bands also. This is a *plumata* pattern. Albino shells are also found. Specimens of Gulick's Keawaawa lot measure:

Length 20.5, diam. 12 mm., 6⅓ whorls.

Length 23.2, diam. 13 mm.

Length 22.5, diam. 14 mm.

Gulick's collection was no doubt from rather low, where the forest was already almost gone in his time. Higher up, in the bottom of the ravine next to the head of Kuliouou, Mr. Spalding found living shells on dead kukui trees, in some abundance, in 1908 to 1910. Some of these are figured, pl. 43, figs. 1 to 1*d*. The white, the two-banded, the split-banded and the streaked patterns are about equally prevalent. The white shells are more or less tinted behind the lip, and around the root of the columellar fold. Banded shells often have the fold wholly white.

Length 25.2, diam. 13.2 mm., 7¼ whorls.

Length 24, diam. 13.5 mm., 7 whorls.

Length 20.6, diam. 12 mm., 6¾ whorls.

Length 18.8, diam. 12.4 mm., 6 whorls.

Northward, across the range, *A. phœozona* is probably now extinct. About sixty years ago Gulick found it in small numbers in Waimanalo (similar to pl. 36, fig. 10*a*), in Kailua and on Olomana. The Kailua specimens (no. 589 Boston Soc., pl. 36, figs. 9, 9*a*), are rather small, length 20 to 21 mm., and mainly slender; but others of the same lot are typical in contour, similar to fig. 10*a*. Of the specimens from the Koolaupoko side Gulick writes: "Smaller, with outlines of spire less convex; passing into *A. plumata*. Average weight 5.3 grains. Habitat: vars. *i-k* in Kailua; vars. *l-o* in Olomana. *Var. i.*—white with numerous chestnut bands on the lower part of the whorls. *Var. j.*—Light olive brown with dark bands. *Var. k.*—Dark brown with narrow white bands."

Olomana is a shapely and elegant peak terminating the butress thrown out between Kailua and Waimanalo. Here Mr. Gulick found a few *phœozona*, for the greater part small and slender, with bands or lines of carob brown below the periphery, or sometimes above also (pl. 48, figs. 19, 20, Boston

Soc. N. H. coll.). Also white, of the ordinary *phœozona* shape and size, in contour like pl. 24, fig. 11. No tree snails are now to be found on this peak. Mr. Gulick notes the following patterns. "*Var. l.*—White with one or two broad black bands at the base. *Var. m.*—Elongate, white with two black bands, one revolving above the suture, the other entering the aperture, and sometimes a third accompanies the sutural margin. *Var. n.*—White with from three to five crowded bands at the base. *Var. o.*—Pure white."

On the base-leveled plain north of Olomana, about half a mile from the sea southeast of Kailua Bay, Mr. Spalding found *phœozona* of normal size and marking in the humus turned up by the plow in a grove of young coconuts, west of the stream. While one would not expect land shells to withstand disintegration for many years, it must be a century, and probably much more, since forest suitable for tree snails existed in this place. It will be inferred from the planting of coconuts that the plain lies only a few feet above sea level. The situation is however a dry or semiarid one for the Koolau side. East of the stream in this plain I have found rather rich deposits of fossil land shells, including *Amastra* and *Leptachatina*.

15. A. BUDDII Newcomb. Pl. 36, figs. 7 to 8*a*.

"Shell sinistral, conically ovate, solid; whorls 6, convex, slightly margined above; suture moderately impressed, banded with white; aperture ovate; lip acute, thickened within; columella short, with a terminal plication. Color yellowish (or cinnamon) slate or fawn; columella and aperture white. Length 16/20, diam. 9/20 inch" (Newc.).

Oahu: Waialae (Gulick); Palolo (Newcomb, type loc.; Gulick); Manoa (Emerson); Head of Makiki (Spalding, Thurston, Cooke, Pilsbry and others).

Achatinella buddii NEWC., P. Z. S. 1853, p. 155, pl. 24, f. 73. —PFR., Monogr. iv, 538; vi, 173.—GULICK, Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 16 (Makiki).—*Achatinella fuscozona* Smith, GULICK and SMITH, P. Z. S. 1873, p. 76, pl. 9, f. 9.

In shape *A. buddii* does not differ materially from the widest specimens of *A. fulgens. The apex is dark.* The columellar fold is often smaller and generally vinaceous. The chief difference is one of color; in *buddii* the shell in its more primitive pattern is closely streaked with liver brown to purplish vinaceous, flesh color and whitish or creamy, or with flesh-tint or yellowish brown alone, on a paler ground, the sutural margin self-colored or narrowly white. The streaks are sometimes continuous, but usually the pattern is varied by darker or lighter spiral zones, or interrupted by white bands or zones, and there are occasional albino individuals. Through various stages, there is a passage to the banded pattern, in which there are spiral bands and lines of chestnut brown or blackish brown on a white or buff ground, often shading towards the base to cream-buff, sometimes streaked with brown. Often there is a very faint brownish line below the suture, and in the rare mutation described as *A. fuscozona*, there is a subsutural chestnut band. The embryonic shell is often brown with a wide white or pale zone below the suture; and when white it always has a dark tip, even in albinos. In *A. fulgens* the embryo is white as a rule, but sometimes it has a dark tip. Specimens of *buddii* from Waialae, Palolo, pl. 36, f. 7 to 7*e*, and Makiki, pl. 36, f. 8, 8*a*, do not differ materially.

A. buddii was formerly not uncommon in Palolo, where large numbers were collected by Newcomb, Gulick and doubtless many others. The supposed *A. fuscozona* recorded by Messrs. Gulick and Smith from Palolo have no direct connection with the *fuscozona* of Makiki, but are an independent though somewhat similar form of *buddii.* There is a very pale sutural band of a light ochraceous-buff tint, on a straw yellow or nearly white ground, and the apex is that of typical *buddii.* The specimens are no. 678 of Gulick's collection, and no doubt were selected out of his Palolo lot of *buddii.*

About 1855 Mr. J. S. Emerson collected an ample series in the bottom of Manoa valley on the Sugar Loaf side, above where Dr. Cooke's house now stands, in a grove of kukui trees then being cut by Chinese to obtain *pepeitao-laau,* an

edible fungus. The shells are of the streaked and also the banded patterns. These localities have long since been deforested, and the species is now to be found only high in Makiki, where the banded pattern, pl. 36, fig. 8*a*, prevails. A few specimens which had escaped shell collectors could still be found hiding in knot holes and crevices in the bark of certain old kukui trees, when Doctor Cooke and I visited the place in 1913. It seems to be a shell of the kukui zone, probably not found at greater elevations.

An unusual pattern of *buddii* was selected to form the supposed species *fuscozona*. The description follows, with notes on the type and other specimens. It seems to be a mutation which did not become general in occurrence. There are many instances where a particular pattern has been found on a few trees only.

Color var. *fuscozona* Smith. Pl. 38, fig. 15. "Shell sinistral, ovate-conic, perforate, slightly shining, striated with growth lines and (under the lens) very minute transverse lines; whitish, more or less streaked obliquely with light brown, and transversely indistinctly lined and zoned; suture distinctly margined with brown; whorls 6½, convex, the last one ample; apex blackish; aperture white, peristome thin, lightly bordered within; columellar fold strong, reddish (sometimes whitish). Length 21, diam. 12 mm.

" Var. Shell long-conic; suture girdled by a very wide brown zone. Length 23½, diam. 11 mm.

" Station: on the trunks of trees.

" Habitat: Makiki, on Oahu. Two or three specimens have been found in Palolo. Affinities: It is intermediate between *A. adusta* Rv. and *A. buddii* Nwc." (*Smith*).

The type-specimen is figured, pl. 38, fig. 15. It is no. 75 of Gulick's type series, Boston Society. The original figure shows the aperture too narrow, and the two lines near the middle of the last whorl too strong. They are barely visible. The shell is white, pale buff behind the outer lip and on the parietal wall of the aperture, where several darker, isabella colored lines or narrow bands are indistinctly visible. The first half-whorl is ocher-red, the next whorl violet-plumbeous

in the lower half, fading to white above. This dusky tint fades on the following whorl. The last three whorls have a chestnut border below the suture about ½ of a millimeter wide. The subsutural furrow bisects this border. The aperture and columella are white, exactly as in *A. buddii.* There is a very small dark area below the columellar reflection which makes it appear perforate, but it is not really so. Length 21, diam. 12.3 mm., with 6¼ whorls.

In his collection Mr. Gulick selected specimens of *buddii* having a brown subsutural band and segregated them as *fuscozona.* Altogether he had about a dozen, found among perhaps a couple of hundred *buddii.* They vary in pattern from that of the type of *fuscozona* to specimens like pl. 36, figs. 7*a*, 7*c*, except that they have the sutural band. A few are very small, length 18, diam. 9.5 mm., with 6⅓ whorls.

In one of Mr. Gulick's lots from Makiki, no. 804 Boston Soc., there is one *buddii* with a wider sutural band and slightly purplish-brown columellar fold, and four *stewartii* of unusual pattern, two of them figured in pl. 38, figs. 16, 16*a*. This is what Mr. Smith described as a long variety of *fuscozona.*

Having examined nearly all the *fuscozona* ever taken by Gulick, including the type, I am satisfied that Mr. Sykes was right in placing it as a synonym under *A. buddii.* It has nothing to do with *stewartii,* except that Mr. Gulick mixed them in one of his lots.

16. A. FULGENS Newcomb. Pl. 36, figs. 1 to 6*e*; pl. 37, figs. 1 to 9; pl. 43, figs. 2 to 4*c*.

"Shell elongately conic, polished, shining; whorls 6, flatly convex; suture slightly impressed; aperture ovate; columella short, tuberculated; lip simple, ribbed within; color rich chestnut-brown, with a broad white sutural fascia cutting the center of the last whorl; apex and columella white. Length eighteen, diam. eight-twentieths inch." (Newc.)

"Var. *a*, white with broad chestnut bands." (*Newc.*). Pl. 29, fig. 24.

Oahu: Niu (Newcomb) to the Palolo-Manoa ridge; var. *versipellis* over the range in Kailua.

Achatinella fulgens Newc., Proc. Zool. Soc. London, 1853, p. 131; varieties figured on pl. 22, f. 24, 24*a*.—Pfr., Monographia, iv, p. 537.—*Achatinella liliacea* Pfeiffer, P. Z. S., 1859, p. 31; Monographia, vi, p. 173.—*A. lilaceum* Pfr., Hartman, Proc. A. N. S., Phila., 1888, p. 34.—*Achatinella vulpina* Fér., Reeve, Conch. Icon,, vi, pl. 4, f. 29*a, b, c*.—Thwing, Orig. Descriptions, etc., pl. 1, f. 12. Not of Férussac.—*Achatinella crassidentata* Pfr., P. Z. S. 1855, p. 6, pl. 30, f. 23; Monographia, iv, p. 539.—*Achatinella plumata* Gulick, Annals of the Lyceum of Natural History of New York, vi, p. 217, pl. 7, f. 41, December, 1856; Evolution, etc., p. 41, pl. 2, f. 23 (*Waialae*).—*Achatinella diversa* Gulick, t. c. p., 220, pl. 7, f. 42*a*, 42*b*; Evolution, etc., p. 41, pl. 2, f. 24 (Waialae).—Thwing, Orig. Descript., pl. 1, f. 11.—*Achatinella varia* Gulick, t. c. p. 222, pl. 7, f. 43; Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 21 (Palolo).—*Achatinella trilineata* Gulick, t. c., p. 226, pl. 7, f. 43; Evolution, etc., p. 41, pl. 2, f. 20 (Palolo).—*Achatinella augusta* Smith, P. Z. S., 1873, p. 74, pl. 9, f. 7.—*Achatinella angusta* Sm., Paetel, Catalog, p. 105.—Hartman, Proc. A. N. S. Phila., 1888, p. 33.

A. fulgens comprises particolored, sinistral shells, inhabiting the ridges and ravines between the areas of *A. phœozona* on the east, and *A. stewartii* on the west. It is ordinarily a more slender shell than *A. phœozona*, with the spire nearly straight-sided, and further differs from that by the frequent presence of a yellow or green cuticle. *A. stewartii* is usually more solid, more obtuse above, and differs in color-patterns. It never has white bands, which are frequent in *fulgens*. *A. fulgens* is sinistral as a rule, but dextral as a very rare variation. Probably about half a dozen dextral shells are known. The Kailua race, *versipellis*, is frequently dextral. There are some transitional examples on the boundaries between *phœozona, fulgens*, and *stewartii*, where narrow areas of overlap exist on the western and northern confines of Kuliouou, and in the northwestern ravines of Palolo.

Many strikingly diverse color-mutations have arisen and become more or less generally spread throughout the *fulgens*

area. Nearly every colony is hybrid, and in some the mixture is very complex. If any gametically pure colonies exist, they must be rare. Segregation of the elementary patterns is often incomplete, and in assorting any large lot, one encounters specimens which seem to be blends, often in large proportion.

In general, one may say that forms obliquely streaked and lineate with various shades of vinaceous or cinereous (*plumata* patterns) predominate in the east, and fade out westward, where they finally appear chiefly in blends with other patterns. Green and yellow cuticle is mainly developed in the western district. Some other mutations, such as the *augusta, fulgens* and *crassidentata* patterns, have had their rise in the intermediate district, and have not spread over the whole area of the species.

The numerous names proposed by Gulick and others have no validity in existing taxonomic usage as standing for species or subspecies, because the forms occur only as constituents of mixed colonies, and not as pure strains; even though one or two of the patterns may predominate in one or another colony. These names, however, provide convenient terms for the designation of particular patterns. The chief patterns are as follows. How many of them would turn out to be elementary patterns, if tested by suitable breeding experiments, is of course quite uncertain.

1. *Plumata* pattern. Finely streaked with vinaceous, purple drab or plumbeous gray, pl. 36, figs. 4*a*, 5, 6, 6*a*.
2. *Varia* pattern. White above, yellowish or olivaceous below the periphery; obliquely streaked with cinnamon or tawny; usually with a dark line below the suture. Pl. 36, figs. 1, 1*a*.
3. *Diversa* pattern. Base and a band above the periphery green, olive or yellow, elsewhere white. Pl. 37, figs. 4*a*, 4*c*.
4. *Augusta* pattern. Green or olive with a yellowish or white band below the suture. Pl. 37, figs. 12, 12*a*.
5. *Trilineata* pattern. Yellow below, white above the periph-

ery, with two black bands, one above, the other below the periphery. Pl. 37, fig. 7*a*.

6. *Fulgens* pattern. Chestnut-brown above and below a peripheral white or yellow band, which ascends the spire above the suture. Pl. 37, fig. 1. This is a rare form, but it is what Newcomb selected as typical of *fulgens*.
7. *Crassidentata* pattern. White, with yellow or olivaceous bands below the suture, at the periphery and around the axis, the upper one often wanting. Pl. 30, fig. 23. A rare pattern.
8. *Liliacea* pattern. Albino or albinistic forms occur in some colonies, and may be derived from various patterns.

The typical *fulgens* color-form described by Newcomb is shown in pl. 37, fig. 1, this specimen being from Waialae nui, Cooke collection. Newcomb's original figures, reproduced in pl. 29, figs. 24, 24*a*, represent other color-forms, fig. 24 being Newcomb's var. *a*, while fig. 24*a* is what was subsequently described as *A. augusta*.

Niu.—Plate 36, figs. 4 to 6*e*. The *plumata* pattern of fine oblique, vinaceous cream or slaty-purple lines and streaks over a white, vinaceous, or white-and-yellow ground, is especially characteristic of Niu. Figs. 5 to 5*e* show the patterns in a lot collected by Mr. Gulick. The shells are rather small, 19 to 21 mm. long. There are also shells of the *trilineata* pattern and albinistic specimens in which the brown bands are reduced by absence of the subsutural or the subsutural and basal. A few have no bands (pl. 36, figs. 5 to 5*e*).

A series received from Mr. Thaanum, collected recently, consists mainly of larger shells, pl. 36, figs. 6 to 6*e*. This contains typical *plumata* pattern, fig. 6; *plumata* with yellow cuticle on the base, fig. 6*a*; *plumata* with white and dark bands, fig. 6*b, c*; *trilineata* pattern, fig. 6*d*; and albino forms, fig. 6*e*. There is clear segregation of the elementary patterns in most specimens, but blends are not uncommon, such as figs. 4 and 6*c*, which seem to be blends of *plumata* and *trilineata*.

A large series in Mr. Spalding's collection, from the west-

ern ravines of Niu, includes typical *plumata* and typical *trilineata* patterns, with many intermediate blends. There are also many white *plumata*, like pl. 36, fig. 6*e*. Dr. Newcomb's fig. 24 was evidently from a Niu shell.

Wailupe.—Plate 36, figs. 3, 3*a*; pl. 43, figs. 3 to 3*c*. The Gulick collection contains *plumata* patterns, figs. 3, 3*a*, and others similar to those he obtained in Niu. Also *trilineata* pattern. The *augusta* pattern, pl. 37, figs. 12, 12*a*, was also taken here by Gulick. It is not found in Niu, and has not been taken in Wailupe in recent years.

Recent collections contain streaked *plumata*; *trilineata* like pl. 36, fig. 6*d*; typical *fulgens* pattern; *diversa* pattern; various blends of *diversa-plumata* and *trilineata-plumata* patterns; and beautiful, pure white albinos. There are also a few examples of the *crassidentata* color-pattern, pl. 48, fig. 21. All of these are found in one colony. A few are illustrated, pl. 43, figs. 3 to 3*c*, northwestern valley of Wailupe, collected by Irwin Spalding.

Waialae.—Pl. 37, figs. 1 to 6*b*. Waialae *fulgens* differ from the Wailupe and Niu series by the prevalence of green forms and the decadence of the *plumata* pattern. Very few *plumata* similar to those of Niu, pl. 36, figs. 5-5*d*, are in the Gulick collection, but in more recent collections, the *plumata* pattern occurs in blends with other patterns, such as pl. 37, figs. 3, 3*a*, 5*a*, 6*b*. The *varia* pattern appears here (Gulick coll.) but is much more fully represented in Palolo. The *augusta* pattern with white spire and in various blends with *plumata* and *diversa* is common, pl. 37, figs. 3, 3*a*, Waialae nui, coll. by Thaanum. The *trilineata* pattern is rare or absent, but there is an abundant form with two brownish black bands on a green-streaked ground, pl. 37, figs. 3*c*, *d*, *e*, Waialae nui. The *diversa* pattern, pl. 37, figs. 4*a*, *b*, *c*, coll. by Baldwin, and fig. 5*c*, coll. by Gulick, is abundant. It often blends with *plumata*, as in fig. 3*g*; and there are also beautiful dark green examples with white bands on the spire only, particularly in Waialae iki. Pl. 36, fig. 2 is a dextral specimen from Waialae, coll. by Gulick. The *fulgens* pattern, pl. 37, fig. 1, Waialae nui, coll. by Dr. Cooke, is rare. There are

two broad chestnut zones, leaving a yellow band at periphery and a yellow line below the suture. A beautiful and unique specimen in the Spalding collection, pl. 43, fig. 2, from Waialae iki, has a green-streaked base and a broad chestnut black zone above. Figs. 5 to 6*b* are from specimens taken by Gulick; the other figures of Waialae shells, 1 to 4*c*, are from more recently collected examples. On the Waialae-Palolo division ridge Mr. Thurston collected a fine series of *augusta*, rather small shells. It may be a pure colony.

Palolo.—Pl. 36, figs. 1 to 1*f*; pl. 37, figs. 7 to 9, coll. by Gulick. The *plumata* pattern is rare or wanting in Palolo, where the principal patterns are *varia, diversa, trilineata* and *augusta*. The *varia* pattern, pl. 36, figs. 1, 2, is rather characteristic of Palolo. The shell is streaked obliquely with russet or ecru olive, with an olive-brown band above, the base ecru olive or brownish. In the northern ravines of Palolo this pattern is associated with very fine citron-green and dark green *diversa* with a blackish line below the suture; *diversa* with white bands, with or without a blackish line above the periphery, and albinos. Some of these are shown in pl. 43, figs. 4 to 4*c*, coll. by Spalding. There are also *augusta* with white or streaked spire, mostly with a dark subsutural line.

The *fulgens* pattern is rare (pl. 37, fig. 8*c*). A peculiar modification of the *trilineata* pattern has a very narrow chestnut or blackish line above the periphery, pl. 37, fig. 9, coll. by Gulick. This seems to be a specially Palolo pattern.

The frequent presence of a dark line below the suture indicates affinity to *A. stewartii*. Rare individuals from the northwestern ravine of Palolo are indistinguishable from *A. stewartii*.

Dr. Newcomb defined a " Var. *b*, chestnut colored above, yellowish below, with two black and one white band, with columella dark brown, of large size, measuring 22 x 10 twentieths of an inch. This last variety may upon further examination prove to be a distinct species. The locality of this last is Makika valley, *mauka roa*, or far back in the mountain range." I am pretty confident that Newcomb was mistaken about the locality of this variety. Nothing like it is found in

Makiki, either *mauka* or *makai,* but some Palolo specimens have the coloration described.

16*a*. A. FULGENS VERSIPELLIS Gulick. Pl. 43, figs. 5 to 7*d*.

" Shell dextral or sinistral, imperforate, acuminately oblong, solid, shining, striated, of lively ash-color, more or less streaked and waved with brown, with several interrupted brown bands on the upper parts of the whorls; apex somewhat obtuse; spire convexly conical; suture margined, moderately impressed; whorls 6, convex; columellar fold central, white, strong; aperture truncately auriform, white within, a little oblique, in sinistral specimens very oblique; peristome thickened within; with external margin unreflected, compressed, edged with brown; columellar margin dilated, adnate; parietal margin wanting. Length 20⅓, breadth 10, length of body-whorl 15 mm. Average weight 8.6 grains." (*Gulick.*)

" *Var. b,* rich brown, with light streaks and waves. *Var. c,* yellow at the base, with one or more brown bands above. *Var. d,* yellow at the base and white above, without bands. *Var. e,* nearly pure white. *Var. f,* ash or yellow gray, without bands. A rare and beautiful species, found in the most rugged but verdant region of western Kailua. About a third of the specimens are sinistral." (*Gulick.*)

Oahu: Pohakunui, Kailua (J. T. Gulick). Kailua under Mt. Olympus, and the Kailua-Waimanalo division ridge (Irwin Spalding).

Achatinella versipellis GULICK, Ann. Lyc. N. H. of N. Y., vi, p. 224, pl. 7, f. 44*a, b*. December, 1856.—*Achatinellastrum versipilis* Gul., PEASE, P. Z. S., 1869, p. 646.—*Achatinella fuscolineata* SMITH, P. Z. S., 1873, p. 75, pl. 9, f. 2, and var. *b,* f. 2*a*.

Very closely related to the *plumata* and various other patterns of *A. fulgens,* from which *versipellis* is separated mainly by its habitat, on the north side of the main range, and by the frequency of dextral shells. There is, however, some difference in the patterns; *versipellis* often having the ground color of the last whorl all yellow.

Mr. Gulick's two cotypes are figured, pl. 43, figs. 5, 5*a*. Both are streaked individuals, one streaked with Indian red on a white ground, the other with chestnut on a yellow ground. The apical whorls are very pale yellow in both; columellar fold entirely white. Other specimens from the original lot, pl. 43, figs. 5*b*, 5*c*, have livid brown streaks blending with the light yellowish olive ground, or the dusky streaks may be very faint on an ecru-olive ground. Specimens without streaks may be deep colonial buff with or without interrupted cinnamon bands. Another pattern is pale-pinkish buff with two yellow bands. One shell is white, shading to pale green-yellow at the base, with yellowish lines at suture and above periphery. There is also a *diversa* pattern, with light yellow base and band. I have not been able to locate the type locality, Pohakunui, but it is probably near Mt. Olympus.

Specimens from Kailua, under Mt. Olympus, collected by Mr. Spalding, pl. 43, figs. 7*b*, 7*c*, 7*d*, and others from Maunawili (in the same region, if not the same colony), collected by Mr. Wilder, pl. 43, figs. 7, 7*a*, show further modifications of the patterns found by Mr. Gulick. Among them, Mr. Wilder found a green form, *diversa* pattern.

On the division ridge between Kailua and Waimanalo Mr. Spalding collected various streaked and yellow-banded patterns, all sinistral (pl. 43, figs. 6 to 6*c*).

A. fuscolineata E. A. Smith. (Pl. 43, fig. 8, reproduction of original figure).

"Shell sinistral, ovate-conic, imperforate, glossy, striated obliquely with growth lines and very delicately transversely striate; greenish-yellow streaked with green, and encircled above the periphery with (3 to 5) brown lines; suture distinctly brown-margined. Whorls 6½, convex, the first three white. Aperture white; peristome white (sometimes brown), the margin acute, bordered within; columellar margin strong, roseate (sometimes white). Length 19, diam. 10 mm.

"Var. *a*. Shell more of a green color.

"Var. *b*. Shell smaller, subtestaceous, streaked with pale chestnut and transversely banded above with deep brown." (*Smith.*)

Oahu: the typical form is found in Kailua, but varieties which may conveniently be classed with it are found in nearly all the valleys between Palolo and Halawa (Gulick).

"It is most nearly allied to *A. versipellis* Gulick. This species is very rarely dextral. The specimen figured is from Kailua" (*Gulick*).

Mr. Sykes follows Newcomb in referring this to *A. vulpina* as a synonym. It seems to me to be a banded form of *versipellis*. Like that it is rarely dextral. Shells from other districts than Kailua, referred by Mr. Gulick to *fuscolineata*, are probably forms of *vulpina*, superficially like the Kailua type in markings. Some of them which I have seen from the western valleys are forms of *analoga*; and his "*fuscolineata*" from Palolo are certainly *fulgens*.

16*b*. A. FULGENS AMPLA Newcomb. Pl. 29, fig. 19; pl. 54, figs. 7 to 7*c*.

"Shell dextral, conically ovate, polished; whorls 5, rounded; suture simple, banded with a black stripe; aperture large and white; outer lip simple, acute, thickened within; columella short, white or roseate, terminating in a twisted plait; apex obtuse, roseate; epidermis light green or olive above, of a deeper color on the last whorl. Length 14-twentieths, width 10-twentieths inch" (*Newcomb*).

Oahu: Koolau (Newcomb).

Achatinella ampla NEWC., P. Z. S. 1853, p. 137, pl. 22, f. 19, 1854.—PFR., Monogr. iv, 533.—SYKES, Fauna Hawaiiensis, p. 305, 1900.—THWING, Reprint Original Descr., p. 59.

There is an error, probably typographical, in Dr. Newcomb's measurement; 14-twentieths should be 17-twentieths according to Newcomb's original figure, which is reproduced photographically on pl. 29, fig. 19. Pl. 54, figs. 7-7*c* represent other specimens in Newcomb's collection, no. 29904 Cornell University. The series includes both dextral and sinistral shells. *The very ample last whorl* is the chief characteristic distinguishing *ampla* from the other Koolau races, *phœozona, versipellis* and *fuscolineata*. Some specimens approach very near to such *versipellis* as pl. 43, figs. 7*b*-7*d*,

from Kailua below Mt. Olympus. It must be admitted, however, that there is also a close relationship to *A. stewartii.* Probably *ampla* came from somewhere in Kailua, Newcomb's locality being in a rough way correct.

The last whorl is straw yellow, usually streaked and more or less suffused with green; sometimes with some obscurely traced green bands; the early whorls whitish or faintly flesh tinted. The suture is narrowly margined with chestnut. There is often a blackish chestnut crescent at the columella. In Newcomb's type and one other specimen the whole base is streaked with chestnut.

Length 19.5, diam. 12.6, aperture 9.5 mm.; 6¼ whorls.

Length 20.1, diam. 12.5, aperture 10.5 mm.; 6 whorls.

The original descriptions of forms based upon various mutations of *A. fulgens* are reprinted below. We have examined the types of all but *crassidentata*, *augusta* and *liliacea*, and have seen part of the original lot of *augusta.*

A. crassidentata Pfeiffer. Pl. 30, fig. 23, reproduction of original figure. "Shell imperforate, sinistral, rather solid, striatulate, little shining; white, ornamented with a few buff bands, sometimes having the base greenish-buff. Spire conic, the apex rather obtuse, suture margined; whorls 5½, a little convex, the last about three-sevenths the length, rounded at the base. Aperture diagonal, sinuately semioval; columellar fold superior, very thick, tooth-shaped; peristome simple, the outer margin acute, lightly arcuate; columellar margin short, narrow. Length 20, diam. 11 mm.; aperture 10 mm. long, 5 wide. Inhabits the Sandwich Islands, Frick, in Mus. Cuming" (*Pfr.*).

This pattern has been found by Mr. Spalding in Wailupe. The bands are cuticular, not homologous with those of *trilineata*, which are differently located, and dye the prismatic layer of the shell.

"*A. liliacea* Pfr. Shell imperforate, sinistral, ovate-conic, rather solid, lightly striate, glossy, white; spire a little convexly conic, apex subacute; suture narrowly margined; whorls 6, scarcely convex, the last a little convex, sometimes subangular at the periphery, the base sack-like; columellar fold

pale rose, high, twisted; aperture oblique, reversed auriform; peristome unexpanded, acute, somewhat labiate within; columellar margin slightly dilated, adnate. Length 24, diam. 12 mm. Inhabits the Sandwich Islands, Dr. Frick, in Cuming coll'' (Pfr.).

This is an albino form.

Achatinella plumata Gulick. ''Shell sinistral, imperforate, ovate-conic, solid, shining, striated, cinereous, with oblique brown streaks; apex subacute; spire conic, with outlines slightly convex; suture marginate, moderately impressed, white; whorls 6½, somewhat convex; columellar fold central, white, strong; aperture somewhat oblique, truncately auriform; peristome subacute, well thickened within, with columellar margin dilated, adnate; parietal margin wanting. Length 23 mm., breadth 12.2, length of body-whorl 16, length of aperture 11 mm. Average weight 8.5 grains.

''Station: on the leaves and branches of trees. Habitat: Niu, Oahu, J. T. G.!'' (Gulick).

''Remarks: a neat species, differing from *A. phœozona* in its smaller size, more conic spire, and in the streaked arrangement of its colors. The typical specimens are much thicker and heavier than *A. buddii* Newc., and it never has the black tip of that species. We have seen but one dextral specimen, which has been mentioned under var. *s*.'' (*Gulick*).

Mr. Gulick characterizes 41 color-varieties, grouped under five sections designated by Greek letters.

These sections are as follows: (1) typical, vars. *b* to *k*.

(2) ''Smaller and more elongately ovate. Length 19⅕, breadth 10⅖ mm. Habitat Wailupe, Oahu.'' Vars. *l* to *g*.

(3) ''Of full size, but thinner, than the typical varieties, with the first three whorls usually white; passes into *A. fulgens* Newc., which is found in the same locality. Habitat, Waialae, Oahu; vars. *r, s* and *v* are sometimes found in Palolo.'' Vars. *r* to *x*.

(4) ''Rather thin, with lip acute and scarcely thickened within; pass into *A. buddi* Newc., found in the same locality. Average weight 5.3 grains. Habitat, Palolo, Oahu.'' Vars. *y, z, aa* to *ii*.

(5) ''With spire more convex and colors less streaked; pass into *A. phœozona* vars. *i* to *o*. Habitat Kailua, Oahu.'' Vars. *jj* to *pp*.

It has not been thought desirable to occupy space here

with the descriptions of Mr. Gulick's lettered varieties. Those who have not access to the original publication can find them in Mr. Thwing's *Reprint*, pp. 40, 41. Data so presented serve to show the wide range of variation, but are not otherwise available as variation is now studied.

The few Kailua specimens we have seen seem to be at least as near *phœozona* as *plumata*, although Gulick classed them with the latter. They have the convex-sided spire of *phœozona*.

"*Achatinella diversa* Gulick. Shell sinistral, very rarely dextral, imperforate, ovately or elongately conic, solid, shining, striated, white or variously painted with yellow or green; apex subacute; spire conic; suture marginate, moderately impressed; whorls 6½, somewhat convex; columellar fold central, strong, rose or white; aperture oblique, truncately auriform; peristome acute, thickened within, with columellar margin dilated, adnate; parietal margin wanting. Length 21, breadth 11⅖, length of body whorl 15½, length of aperture 10⅔ mm. An average specimen. Greatest length 25 mm. Average weight 8 grains" (*Gulick*).

"Station, on trees. Habitat, Palolo, Waialae, Wailupe and Niu, Oahu, J. T. G.!"

"*Var. a.*—Pure white, except the columella, which is frequently lilac or rose. *Var. b*—white with one black band. *Var. c*—white with two black bands, one entering the aperture; approaches *A. fulgens* Newc. *Var. d*—white with yellow or green base. *Var. e*—yellow with white bands. *Var. f*—yellow, fading towards the apex. *Var. h*—green, passing into gray or brown towards the apex. *Var. i*—green with white bands.

"Remarks: Differs from *A. plumata* nob. in the character and arrangement of its colors, and from *A. fulgens* Newc. in the absence of the white sutural band and the two broad black central bands which characterize that species.

"The specimens found in Niu do not present the green varieties, but incline more to white, and are also thicker and more ovate in form than those found in Palolo. The average weight of full grown specimens from Niu is about 9 grains, that of the Palolo specimens is 7.2 grains.

"I have six or eight dextral specimens belonging to varieties *d, e, g* and *i*" (*Gulick*).

Achatinella varia Gulick. "Shell sinistral, imperforate, acuminately oblong, solid, shining, finely striated, white,

streaked with brown, with a black line beneath the suture, and green or brown at the base; apex somewhat acute; spire elongately conic; suture margined, lightly impressed; whorls 6, flatly convex; columellar fold central, brown or rose, strong; aperture oblique, truncately auriform, white within; peristome thickened within; external margin unreflected, arcuate; columellar margin dilated, adnate, usually margined with black; parietal margin wanting. Length 21⅗, breadth 10⅖, length of body whorl 14 mm. Length of a large specimen 27, breadth 13 mm. Average weight 6.7 grains.

"Station: On the Kukui (*Aleurites triloba*), Ohia (*Eugenia malaccæcensis*), and other trees. J. T. G.!

"Habitat: Palolo, Waialae, and Wailupe, Oahu. J. T. G.!

"*Var.* b, White above, green or yellow at the base. *Var. c*, Green at the base, white above, with one or more green bands. *Var. d*, Green, brown, or yellow at the base, upper whorls radiated with white and brown, and banded with green or yellow. *Var. e*, Radiated with white, and reddish brown. *Var. f*, White except the suture and columella. *Var. g*, Green or yellow; passing into A. Stewartii Green. *Var. h*, Green with one narrow, white, spiral band, passing just above the suture. *Var. i*, Yellow with white sutures, and a dark brown band revolving beneath. *Var. j*, Chestnut brown at the base, becoming paler towards the apex, with several obscure, spiral, brown lines.

"Remarks: The metropolis of the species is Palolo Valley, where it is very abundant. In Waialae and Wailupe, which lie to the east, it gradually becomes more rare, and disappears in Niu, which has furnished me but one specimen of var. f. In Manoa, on the west, it soon disappears, being found only on the mountain ridge that separates it from Palolo. Dextral specimens are very rare. I have a few from Waialae.

"This shell has been described and figured by Reeve as *A. vulpina* Fér., and others have followed him; but a comparison of his figures with Férussac's leads me to doubt his correctness, and after an acquaintance with the species in their native valleys, I do not hesitate to separate them as distinct. The shell here figured corresponds more nearly to what I have described as variety *c* (*Gulick*).

Achatinella trilineata Gulick. "Shell sinistral, imperforate, ovate-conic, solid, shining, finely striated, white above, yellow or green at the base, with three black bands, one sutural, one entering the aperture, and the other between the two, revolving just above the suture; apex somewhat obtuse; spire conical, slightly convex; suture with narrow margin,

moderately impressed; whorls 6½ rather convex; columellar fold central, white or rose, strongly developed aperture truncately auriform, white within; peristome thickened within; with external margin unreflected, arcuate, acute; columellar margin dilated, adnate; parietal margin wanting. Length 21⅗, breadth 12. Length of body whorl 15 mm. Average weight 8.6 grains.

"Station: On the kukui and other trees. Habitat: Palolo, Waialae, Wailupe and Niu, Oahu. J. T. G.

"*Var. b*, With oblique reddish-brown streaks above, the base green or yellow. *Var. c*, Yellowish or green throughout, excepting the bands. *Var. d*, White at the base, and also above. *Var. e*, Covered with oblique reddish-brown streaks. *Var. f*, Apex tipped with black, passing into *A. buddii* Newc. *Var. g*, Green or yellow, except the black bands, and a narrow line of white. *Var. h*, White, with several fine spiral black lines accompanying the broader bands. *Var. i*, With black bands very broad, occupying half the surface or more. *Var. j*, With two black bands, one sutural, the other passing above the suture. *Var. k*, With two black bands, one sutural, the other entering the aperture; rare. *Var. l*, With several narrow bands on the upper part of the whorls.

"Remarks: Dextral specimens of this species are very rare; I have obtained but two. Varieties *j* and *k* have been found only in Palolo. As in the preceding species, the specimens found in Niu are of the lighter colored varieties, and more solid than those of the other valleys." (*Gulick*).

"*Achatinella augusta* Smith. Shell sinistral, ovate-conic, glossy, striated with very fine growth and transverse lines; green, streaked with darker green and encircled by dark green and rufous lines, ornamented with a yellow zone below the white suture; suture distinctly margined with white; whorls 6½, the first four a little convex, the rest convex; aperture white, peristome thin, tinted with pale brown within; columellar fold strong, brownish rose color. Length 24, diam. 12½ mm.

"Var.—Shell all yellow, encircled below the suture with a white zone.

"Station: on trees. Habitat: the metropolis of this species is Waialae, near the east end of Oahu. It is also found in Wailupe and Palolo. Affinities: This species is on the one hand closely related to *A. plumata* Gk., from which it is distinguished by its green and yellow epidermis, which is entirely wanting in that species, and to *A. fulgens* Newc., from which it differs in being without the broad black bands, which

belong not only to the epidermis but to the solid part of the shell of *A. fulgens*. It has been described by Newcomb and Pfeiffer as a variety of the latter species. Remarks: this species is always sinistral. The specimen figured is from Waialae.'' (*Smith and Gulick*).

The specimen figured as type has the appearance of a *plumata-augusta* blend, the *plumata* pattern appearing on the spire as in pl. 37, fig. 3. A purer expression of the color-form is pl. 37, fig. 12; also pl. 29, fig. 24*a*, which Newcomb figured as a variety of *fulgens*.

16½. A. SOLITARIA Newcomb. Pl. 43, fig. 9.

''Shell ovately conical, dextral; whorls 6, flatly convex; suture slightly impressed; aperture ovate; lip acute, thickened within; columella white, short, broad and abruptly twisted; color light chestnut, with darker longitudinal stripes; green at the base, white sutural band for the last 2½ whorls, brown band on the suture above. Length fourteen-twentieths, width eight and one-half twentieths inch.

''But a solitary specimen of this species has been obtained. Its characters are, however, sufficiently striking to warrant in giving it a place as a distinct species'' (*Newcomb*).

Oahu: Palolo (Newcomb).

Achatinella solitaria NEWC., P. Z. S. 1853, p. 150, pl. 24, f. 60; Annals of the Lyc. N. H. of N. Y., vi, p. 331.

A problematic form, possibly normal, but more likely to be a smoked ''*dunkeri*'' with the suture scraped white. If Newcomb's locality is correct it should be a form of *fulgens*; but a *dextral Achatinellastrum* in Palolo would be rather anomalous though not unique. While it is not likely that *A. solitaria* is a valid species or subspecies, it is given place here because we cannot form a well-founded opinion without seeing the type-specimen. Very few examples are known, two in the Cumingian collection being all that are on record. There are none in Newcomb's collection at Cornell University. The original figure is reproduced photographically on my plate.

17. A. STEWARTII (Green). Pl. 38, figs. 1 to 6*a*, 14, 16 to 21.

The shell is dextral or sinistral, oblong-turrite, solid, glossy,

lightly marked with lines of growth and very faint spiral striæ; variously colored, but the typical pattern is citron yellow fading to white at the summit, with a *black or deep brown band bordering the suture below* on the last 3 to 3½ whorls, and a black crescent bounding the columella; aperture white, the columellar some shade of violet. Whorls about 6½, convex, the last rather short. Outer lip simple or thickened within; columellar fold strong.

Length 22, diam. 11.3, aperture 10 mm., Manoa-Palolo ridge.

Length 24.2, diam. 12.8, aperture 11 mm., Manoa-Palolo ridge.

Length 23, diam. 11.3, aperture 9.5 mm., Manoa-Palolo ridge.

Length 22, diam. 13, aperture 11 mm., Manoa-Palolo ridge.

Oahu: Northwestern Palolo to Makiki and eastern Pauoa.

Achatina stewartii Green, Contributions of the Maclurian Lyceum to the Arts and Sciences, i, no. 2, p. 47, pl. 4, f. 1-4, July, 1827.—*Achatinella stewartii* Green, Reeve, Conch. Icon. vi, pl. 4, f. 26.—Gulick, Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 18 (Manoa).—*Achatinella fuscozona* Gulick, t. c., p. 41, pl. 2, f. 19 (Manoa).—*Achatinella pulcherrima* Reeve, C. Icon. pl. 3, f. 23*a, b*.—*Achatinella venulata* var. *a*., Newcomb, P. Z. S. 1853, p. 146, pl. 23, f. 48.—*Achatinella byronii* Gray, Gulick, Ann. Lyc. Nat. Hist. of N. Y., vi, 1858, p. 244.—*Achatinella johnsoni* Newcomb, P. Z. S. 1853, p. 147, pl. 23, fig. 50.—Gulick, Evolution, etc., p. 41, pl. 2, f. 17 (Manoa).—*Achatinella aplustre* Newcomb, P. Z. S. 1853, p. 147, pl. 23, f. 51.

Professor Green's description of *A. stewartii* included also the forms described later as *producta, castanea,* and *johnsoni.* His shells were probably from Makiki and the slope of Mt. Tantalus, and perhaps also from eastern Manoa, as the clear-yellow ground of part of his figures is much like Manoa-Palolo ridge shells. Later authors have restricted *stewartii* to the yellow or green form with black sutural band such as pl. 38, fig. 1, agreeing exactly with Green's fig. 2, which may be selected as his type. Pl. 38, figs. 2 to 3 are sinistral forms of similar pattern.

A. stewartii differs from *A. s. producta* by being narrower, the last whorl shorter and a little compressed, the spire more turrited, and the suture always bordered with black. It differs from *fulgens* by lacking white bands, by the dark suture, and various peculiarities of pattern more readily appreciated than described. *A. vulpina* and *A. stewartii* are very intimately related, but in general, *A. stewartii* is either sinistral or dextral, larger, more turrited, and when melanistic the dark hue is in bands. *A. vulpina* is smaller, more oblong-ovate, the melanism is sometimes more generally diffused; typically it has no dark sutural band, and is sinistral (with rare exceptions).

So far as I know, all *stewartii* colonies are hybrids of several elementary patterns, as follows:

1. From deep colonial buff to malachite green, with dark sutural band and columellar patch. Pl. 38, figs. 1, 2-3. *Stewartii* pattern.
2. Olive-ocher or greenish, closely streaked with cinnamon, and with sutural and columellar black bands. Pl. 38, fig. 4. Similar to the *dunkeri* form of *producta.*
3. Ground-color like either of the above, but having four blackish bands. Pl. 38, figs. 4*a* to 6*a*. *Johnsoni* pattern.

Palolo, in the head of a *makai* branch, in the western ravine on the Manoa ridge, pl. 38, figs. 1 to 2*b* coll. by Pilsbry; fig. 3, coll. by Wilder, is a prolific locality for all of the above-described color-forms. Most of the specimens are sinistral.

Towards the main range or "*mauka*" from the well-known *stewartii* ravine on the Palolo-Manoa ridge, Mr. Spalding found a colony which unites *stewartii* and *fulgens*. It contains the following patterns: *stewartii* forms 1 and 3, *trilineata, diversa* and *varia* with dark sutural line. All are sinistral. This has the appearance of a *fulgens* (*varia*) colony hybridized with *stewartii*. Mr. Thurston has collected *stewartii-diversa-plumata* patterns in the same region.

In north-eastern ravines of Manoa the patterns are similar to those of Palolo; typical *stewartii,* streaked, and banded, but most of the shells are dextral (pl. 38, figs. 4, 4*a,* Cooke

coll.). Gulick specimens from Manoa, exact locality not specified, show the same patterns (pl. 38, figs. 5, 6, 6*a*). There are also a few of the *stewartii* pattern suffused and streaked with pink. Mr. Spalding has also collected *stewartii,* forms 1, 2 and 3, on the Manoa side of the Manoa-Palolo ridge.

Makiki valley has various forms not found on the Manoa-Palolo ridge. A series is shown in pl. 38, figs. 14, 19 to 19*c*, coll. by Gulick; fig. 17, Cooke coll., and figs. 18, 18*a*, from Thaanum. The usual pattern has an ochraceous-orange tone, shading towards burnt sienna on the latter part of the last whorl (fig. 18), or there may be two dark lines or bands (fig. 19*a*), or the bands may unite to form a broad black-brown zone (fig. 19*c*), or the whole lower part may be blackish (fig. 18*a*) or chestnut (fig. 17); all having the blackish border below the suture. Reeve's *A. adusta* has the same pattern. Other lots in the Gulick collection have four blackish bands on a citron or colonial buff ground, the shell dextral (fig. 14). There are also Makiki specimens like pl. 38, figs. 1*b*, 4*a* and 5.

Rarely *A. stewartii* occurs with white ground and the usual sutural and columellar bands and purplish columella. One lot from Makiki in the Gulick collection contains a specimen with the ground pure white; one white with the base pale yellow, the whole faintly streaked with pale pinkish cinnamon (pl. 38, fig. 16), another similar but having an incomplete zone of chestnut streaks below the middle, and some paler lines, (fig. 16*a*). These shells were thought by Gulick to be *A. fuscozona*, but I feel sure that they are *stewartii.*

Near the top of Mt. Tantalus there is—or was—a handsome form with the last whorl chestnut-black, lighter or yellow below the black sutural border (pl. 38, fig. 20, Cooke coll; fig. 21, Gulick coll.). It approaches *A. vulpina*, but seems to be a melanistic form of *stewartii.*

17*a*. A. STEWARTII PRODUCTA Reeve. Pl. 38, figs. 7 to 13; pl. 43, figs. 10 to 10*b*.

"Shell somewhat elongately conical, dextral; whorls convex, slightly margined at the sutures; columella conspicuously callous-toothed; apex rather small. Olive-green, apex, colu-

mella and interior of the aperture white. Sandwich Islands'' (*Reeve*).

Length 27, diam. 14 mm. (from figure).

Mt. Tantalus, from the rim of the ''bowl'' or crater to the head of Makiki valley; also on the Pauoa slope down to about 1100 ft.; on the bark of kukui, ti, guava and other trees and bushes.

Achatinella producta Reeve, Conchologia Iconica vi, pl. 2, f. 13, April, 1850.—Gulick, Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 15 (Makiki).—Thwing, Orig. Descript. pl. 1, f. 13.—*Achatinella bilineata* Reeve, C. Icon. vi, pl. 3, f. 22, April, 1850.—*Achatinella venulata* Newcomb, P. Z. S. 1853, p. 146, pl. 23, f. 48*a*.—*Achatinella hybrida* Newcomb, P. Z. S. 1853, p. 147, pl 23, f. 52.—*Achatinella dunkeri* Cuming MSS., Pfeiffer, P. Z. S. 1855, p. 208; Monographia iv, 531.—Gulick, Evolution, etc., p. 41, pl. 2, f. 14 (Makiki).—*Achatinella vulpina* Fér., Gulick, Ann. Lyc. vi, p. 1858, p. 244; not of Férussac.

A. s. producta is a larger, more capacious form than *A. stewartii*, the last whorl more rotund, and the suture usually *without a dark border*. The typical form is dextral, of a clear primrose-yellow tint (varying however in different individuals from colonial buff to green), with the summit, aperture and columellar fold white. The lip is a little thickened within. Sometimes the periphery is indistinctly angular. Size generally large.

Length 27, diam. 14.2 mm.; 6¾ whorls (fig. 7).

Length 25, diam. 13 mm.; 7 whorls (fig. 9).

Length 21.5, diam. 12.3 mm.; 6⅓ whorls.

In the head of Makiki valley the shells are usually dextral (fig. 9), rarely sinistral; on the summit of Tantalus they are all sinistral (figs. 7 to 8*a* southeastern rim of ''bowl''). On the Pauoa slope of Tantalus all are dextral. The size is sometimes not greater than that of *A. stewartii*. The chief color-patterns are:

1. *Producta* pattern, pl. 38, figs. 7, 9, described above.
2. *Dunkeri* pattern, pl. 38, figs. 7*a* to 7*c*. Streaked with

cinnamon over an ochraceous buff or naples yellow ground, sutural border paler, not streaked; often with black band ii, or ii and iii; columella white.

3. *Bilineata* pattern, pl. 38, fig. 10. Having the upper dark band split, ground-color as in *producta*; or there may be two dark bands on the *producta* ground (fig. 8).
4. *Melanistic* forms, pl. 43, figs. 10, 10*a*, 10*b*, in which the dark bands occupy most of the surface.

So far as I know, none of these patterns occur as pure colonies. The common association is *producta* and *dunkeri*. Figs. 7 to 7*c* were found by the writer on the base of a guava bush, within a few inches of one another, together with several young ones. Figs. 8, 8*a* were lodged side by side on an adjacent bush, on the east rim of Tantalus bowl. As the guava bushes here are isolated, singly or by small groups, in a knee-high growth of Hilo grass, there can be no doubt that the shells on each bush or group of bushes are an intergenerant group.

While most lots can be assorted by patterns, blends are rather common. The *dunkeri* streaks may be excessively faint, or they may be well developed in the early neanic stage, but disappear in the later whorls, as in pl. 38, fig. 8*a*.

The *bilineata* and melanistic patterns are not properly elementary patterns. *Bilineata* is of sporadic occurrence. The split band is usually the upper, sometimes the lower. It occurs also on shells with green ground (fig. 11) and on those with *dunkeri* pattern, but is rather rare.

The melanistic forms, such as pl. 38, fig. 13, Cooke coll., and pl. 43, figs. 10, 10*a*, 10*b*, Thwing coll., Bishop Mus., are extremely rare, perhaps now extinct, and probably all from the Pauoa side of Tantalus.

Pl. 38, fig. 9 was found on the base of a kukui tree, concealed by the high grass, in upper Makiki valley. Higher up Tantalus they are found in similar situations on guava and other shrubs and trees. They often rest in groups of three or more on the lower side of the trunk or branches, concealed by grass or other herbage.

Part of the patterns of *producta* are nearly or quite identical with *stewartii* patterns, and would seem to belong to an older period than that of the differentiation of *producta*.

The original descriptions of the several forms referred to *A. stewartii* and *A. s. producta* here follow.

"*Achatina stewartii* Green. Shell heterostrophe, conical, oblong, about one inch in length and half an inch in diameter; whorls 6 or 7, rounded and marked with numerous oblique and delicate striæ; apex rather obtuse and not eroded; a deeply impressed line along the upper part of the whorls parallel to the suture. Periostraca smooth and very glossy. Color and marking exceedingly various; the ground color is usually greenish or some shade of yellow; sometimes a single blackish colored band accompanied the suture; sometimes this band is double and of different shades, and on many specimens there are two bands, one at the suture, and one in the middle of the whorls. In some varieties the base of the body-whorl is dark brown, the rest of the shell being of a dark fawn, and not infrequently the whole shell is without any markings whatever, in which case the color is yellow. The aperture when inverted is ear-shaped; the truncation of the columella is rounded and thickened in a remarkable manner at its edge; along the inner margin of the outer lip there is a strong callous ridge, as in most of the species of this genus, which gradually attenuates towards the edge of the lip, which is thin and sharp inside, white and pinkish around the columella." (*Green*).

Oahu, on under side of leaves of the *ti* plant (Rev. C. S. Stewart).

Achatinella dunkeri Cuming, Pfr. "Shell imperforate, oblong-turrited, rather solid, smooth; pale flesh colored, ornamented with close brownish streaks, and frequently encircled by one or two black lines. Spire turrited, the apex rather acute, white; suture lightly margined, pale. Whorls 6½, slightly convex, the last almost two-fifths of the length. Aperture oblique, truncate-auriform; columellar fold white, strong, tooth-like, subsulcate; peristome unexpanded, acute, white-lipped behind the brownish edge. Length 24, diam. 11 mm.; aperture 10 mm. long, 5 wide. Sandwich Is., Dr. Newcomb (*Pfr.*).

"*Achatinella bilineata.* Shell oblong-conical, dextral, rather ventricose towards the base, whorls rounded, columella dentately plicate; bright yellow, conspicuously encircled round

the middle with two close black lines. Hab. ——? The form of this shell is peculiar, and there is something equally characteristic in the marking'' (*Reeve*).

Our pl. 38, fig. 10 is practically identical with Reeve's figure of *bilineata*.

Achatinella venulata (pl. 30, figs. 48, 48*a*, photographic reproductions of the original figures). ''Shell dextral, elongately conic; whorls 7, convex, slightly margined above; suture well-impressed; aperture subovate; lip simple, thickened within; columella strongly plicate, twisted, of a pinkish hue; color of shell white, or pinkish white, with longitudinal veins of green or olive-green epidermal matter. Length 21/20, diam. 10/20 inch.

''Var. *a*. Sinistral, with a deep black sutural band.

''Kolau, Oahu.'' (*Newcomb*).

This is an artifact so far as color is concerned, produced by scraping *A. producta*; var. *a* is a scraped *A. stewartii*. The following three forms, *johnsoni, aplustre* and *hybrida* are also manufactured patterns. *A. venulata* and *hybrida* were from Mt. Tantalus shells, perhaps *johnsoni* and *aplustre* also. The locality ''Kolau,'' given for the whole series, was a further deception on the part of the shell-artist who imposed the frauds upon Doctor Newcomb.

Achatinella johnsoni (pl. 30, fig. 50, reproduction of original figure). ''Shell dextral, conically elongate; whorls 7, slightly rounded, superiorly indistinctly margined; suture rather deep; aperture subovate; columella with a strong plication, pink, margined with black; color of shell white or pinkish, banded with two or more narrow black lines, one or two of which are central, one sutural, and one usually broader, inferiorly on the last whorl. Length 18/20, diam. 9/20 inch.

''The following form an allied group: *A. producta, hybrida, aplustre, venulata* and *johnsoni*. This species is dedicated to the Rev. Mr. Johnson of Kawai, whose assistance in my researches I most thankfully acknowledge'' (*Newcomb*).

A. johnsoni and *A. aplustre* have somewhat the shape of *A. s. producta*, and may have been manufactured from a rather unusual form of that from Mt. Tantalus, such as pl. 38, fig. 13; but the presence of both sutural and columellar dark

bands is more suggestive of the four-banded pattern of *stewartii*, such as pl. 38, fig. 6.

Achatinella aplustre (pl. 30, fig. 51, reproduction of original figure). "Shell conical, dextral; whorls 7, rounded; suture moderately impressed, simple; aperture semiovate; lip thin; columella with a callus, terminating in a twisted plait, bluish-white, tipped with brown; three first spiral turns white, the others with a broad central pink band margined by two deep black bands; on the last whorl, superiorly and inferiorly, is a broad bright green band. Length 1, width 10/20 inch. Kolau, Oahu.

"The gaudy coloring of this species alone separates it from the *A. johnsoni, nob.* It belongs to the same section with *A. producta* Reeve, which may be taken as the type of a group of species numbering some half-dozen, and which requires still farther additions to render it complete" (*Newcomb*).

This was soon recognized as a scraped and dyed *stewartii* or *producta.*

Achatinella hybrida (pl. 30, fig. 52, reproduction of original figure). "Shell dextral, conical; whorls 6, rounded, margined above, the last somewhat inflated; suture well-impressed; columella white or brownish, terminating in a twisted plait; aperture ovate, white; lip simple, thickened within; striæ longitudinal, fine; color of shell green, or brown on the last whorl, above white, with fine longitudinal veins of the color of the epidermis. Length 18/20, width 10/20 inch. Kolau, Oahu.

"This species seems to be intermediate between *A. producta* Reeve and *A. venulata.*" (*Newcomb*).

18. A. VULPINA (Férussac). Plates 39 and 40; pl. 41, figs. 5-7.

The shell is ovate-conic, smaller than *A. stewartii* (compare plates 38 and 39); glossy; yellow, green, olive or chestnut, often banded with green or chestnut; usually sinistral.

Oahu: Makiki to Manana valleys.

Helix vulpina FÉRUSSAC, (Prodrome, no. 429, no description), in Freycinet, Voyage autour du Monde, sur l'Uranie et la Physicienne, Zoologie, p. 477, pl. 68, f. 13, 14, 1824; Histoire Nat. Moll. Terr. pl. 155, f. 1, 2.—*Achatinella vulpina* Fér., PFEIFFER, Monographia, ii, 237; iii. 464.—*Achatinella castanea* REEVE, Conchologia Iconica, vi, pl. 3, f. 24, April,

1850.—Gulick, Evolution, Racial and Habitudinal, pl. 2, f. 12.—*Achatinella adusta* Reeve, C. Icon. pl. 4, f. 30, April, 1850.—*Achatinella ernestina* Baldwin, Proc. A. N. S. Phila. 1895, p. 217, pl. 10, f. 5, 6.—*Achatinella olivacea* Reeve, C. Icon. pl. 3, f. 20, April, 1850. (Hab. ——?).—Gulick, Evolution, etc., p. 41, pl. 2, f. 13.—*Achatinella prasinus* Reeve, C. Icon. pl. 4, f. 27, April, 1850 (Hab. ——?).—*Achatinella virens* Gulick, Ann. Lyc. Nat. Hist. of N. Y., vi, p. 254, pl. 8, f. 73, Feb., 1858.—*Achatinella cucumis* Gulick, t. c., p. 225, pl. 7, f. 45, Dec. 1856.—*Achatinella analoga* Gulick, t. c., p. 227, pl. 7, f. 47, Dec., 1856; Evolution, etc., p. 41, pl. 2, f. 9 (Halawa).—*Achatinella longispira* Smith, P. Z. S. Lond. 1873, p. 73, pl. 9, f. 5.—*Achatinella colorata* Gulick, Evolution, etc., pl. 2, f. 10 (= *virens*).

A. vulpina as here understood comprises shells of a great variety of colors and patterns, the shape and size of the shells remaining practically the same. Numerous "species", based chiefly upon color characters, have been based upon forms of *vulpina*, but the prevalence of undoubtedly hybrid colonies in which several of them live together opposes that interpretation of the facts, even though the hybrid colonies segregate into patterns so distinct that they may usually be assorted readily, with only a small proportion of "blends." Some of the "elementary species" or patterns rarely occur also in pure colonies, which by themselves would be considered subspecies. Others, like *A. longispira* are found only in hybrid colonies, and seem to be products of hybridism in which the parental patterns are changed rather than blended.

The western edge of Nuuanu valley marks the division between the western and the eastern herds. The dark *olivacea, virens* and *longispira* patterns have not crossed the floor of the valley eastward, and the *vulpina* patterns (typical *vulpina, ernestina* and *adusta*) spread no further west. We would signalize this fact in distribution by dividing the series into two species were it not that the light *olivacea* pattern is common to both herds, extending from Kalihi at least as far west as Waimano, though not common we believe west of the Nuuanu-Kalihi ridge.

It appears that an ancestral stock, probably not unlike the yellowish form of *virens*, spread over a considerable area; various mutations arose in different places, and radiated from their initial points as far as time and conditions allowed, hybridizing with other mutations. Nuuanu, deeply cut, with a broad level floor, has been a partial barrier to the spread of mutations reaching it during the present climatic cycle.

The races from the northern or Koolau valleys have long been in a measure isolated from those of the Kona slope. Intrinsically these races are on a par with the elementary patterns of the southern watershed, but by favor of their isolation they have not been caught in the web of hybridism which clings about the Kona forms. They may properly be recognized as subspecies. See page 224.

Races and elementary patterns of A. vulpina.

(No dark sutural border.)

Chestnut or blackish below, gradually paler towards the suture, *vulpina* pattern, pl. 39, f. 1, 1*a*.

Upper third of last whorl yellow, lower two-thirds chestnut, the division abrupt, *castanea* pattern, pl. 39, f. 2.

Yellow, uniform, or (typically) banded with black-brown, N.-E. Nuuanu, *ernestina* pattern, pl. 39, f. 3-4.

Green, either dark or pale, varying to olive or ochreous, *olivacea* pattern, pl. 40, figs. 3-4*a*. A form in which the shell is somewhat rugose has been named *cucumis* Gul.

(A brown or blackish sutural border.)

Kona forms.

Base dark chestnut, upper surface lighter or yellow, Pauoa, *adusta* pattern, pl. 40, figs. 1, 2.

Green, varying to chestnut or yellow, sutural band narrow, *virens* pattern, pl. 40, figs. 5, 5*a*.

Similar, but with a broad sutural band and rarely another above the periphery, Kahauiki, *suturalis* pattern, pl. 40, figs. 9-10*b*.

Having blackish-brown bands i, ii and iii in the prismatic

layer of the shell, sometimes increased by splitting of bands, *analoga* pattern, pl. 40, figs. 15-15*c*.

Having green and brown lines on a paler ground, *longispira* pattern, pl. 39, figs. 12*c*, *d*.

Koolau forms.

Ground yellow above, ochraceous-orange below, with a broad green zone above the periphery; or dusky without a green band, pl. 41, figs. 8-8*c*. *A. v. colorata*, no. 18*a*.

Ground-color white above, greenish or olive-brown below the periphery, with a sharply defined cinnamon band above the periphery, pl. 37, figs. 10-11*b*. *A. v. tricolor*, no. 18*b*.

Probably the test of breeding would show that not all of the above-defined patterns are elementary. The *castanea* pattern is often not readily separable from *vulpina*. *Adusta* seems to be a *stewartii-vulpina* hybrid. *Longispira* also may be a product of hybridism rather than an elementary pattern.

Usually two or more patterns occur in one colony or often on one tree, and in any large lot there may be some blends or unusual patterns.

Table showing distribution of the elementary patterns of A. vulpina.

Valleys.	Adusta.	Vulpina.	Castanea.	Ernestina.	Olivacea.	Virens.	Suturalis.	Analoga.	Longispira.
Manana						*			
Waimano					*	*			
Waiau					*	*			
Waimalu					?	*			
Aeia					*	*		*	*
Halawa					*	*		*	*
Moanalua					*	*		*	*
Kahauiki					?	*	*	*	*
Kalihi					*	?			*
W. Nuuanu					*	*			*
E. Nuuanu		*	*	*	*				
Pauoa	*	*	*		*				
Makiki	*	*	*		*				

West to Kahauiki the shells are invariably sinistral. From the western ridge of Kahauiki westward a few dextral individuals occur sporadically in the colonies, though sinistral shells predominate.

Typical form.—A. vulpina was originally based upon rather small specimens about 19 mm. long, of a pattern which was subsequently considered by collectors to be a variety of *castanea* Reeve. The types were somewhat faded, either by weather or the application of heat in cleaning, to a reddish or fox color, which suggested the name. Férussac also figured a variant having a darker band over the lower two-thirds of the last whorl. Subsequently, in the *Histoire*, Férussac figured a large specimen of uniform tawny reddish color, length 25 mm., probably from the Pauoa slope of Tantalus. The original description follows.

"Shell sinistral, conic, elongate, vertex obtuse; glossy, sharply striate; epidermis fulvous or rufous, fugacious, the apex pale. Whorls 5½, a little convex; suture distinct, duplicate. Aperture semilunate, white; peristome thickened within; columella white or rose, arcuate; umbilical crevice not distinct.

"*a*, Rufous, unicolored. *b*, Rufous with a broad brown band. It inhabits the Sandwich Islands" (*Fér.*). Length 19, diam. 10 mm. (from type figure).

This typical form ranges from Makiki to Nuuanu valley.

Pl. 39, fig. 1 represents a shell from Nuuanu valley, coll. C. M. Cooke, exactly agreeing with Férussac's type (represented, I take it, by his fig. 13). It is deep chestnut colored, darker towards the base, becoming lighter upwards, the first three whorls buff. There is no dark sutural border. The surface is very glossy, distinctly marked with growth-striæ on the last 3½ whorls; embryonic whorls very delicately striate spirally. Length 19, diam. 10 mm., 6¼ whorls. Other specimens of the same lot are larger, up to 21 mm. long, and most of them are less slender. The columella varies from pale lilac to nearly white. A large specimen measures, length 23.5, diam. 13 mm. It is of course clear that the *historic* type-form of *vulpina* is an abberrant melanistic variation of a species more normally represented by *virens*.

Very often the color fades to yellow at the suture, or the change to yellow may be abrupt, as in pl. 39, fig. 1*a*, which agrees with Férussac's variant *b*. This leads to the pattern figured by Reeve as *A. castanea*, which is represented by pl. 39, fig. 2, Gulick coll., from the Pauoa side of Nuuanu. The same form is also found in Pauoa, pl. 40, fig. 1*a*.

A. vulpina extends eastward to Makiki valley, where the chestnut or blackish form with yellow band above occurs in the northern branch, together with the *dunkeri* pattern of *producta* (L. A. Thurston and Irwin Spalding). Some of the shells have the rim within the lip rather thick. *A. v. olivacea* has been taken in Makiki by Gulick, and recently by Mr. Thurston in the middle branch. On the Manoa base of Tantalus Mr. Thurston found *olivacea* associated with *producta, johnsoni* and *dunkeri*.

Pauoa. The prevalent form is the *adusta* pattern (pl. 40, fig. 2, copy of Reeve's figure; figs. 1, Gulick coll.). The base is chestnut, or isabella, with a chestnut band; above the periphery it is deep colonial buff or ecru-olive, sometimes more or less suffused with chestnut or green. There is a narrow band below the suture, usually blackish chestnut, rarely russet. Probably Reeve's type of *adusta* was from Pauoa valley. The *castanea* pattern (pl. 40, fig. 1*a*, Pauoa, coll. by Gulick) is also found.

The *adusta* pattern of Pauoa and the slope of Tantalus is a transition form to *A. stewartii*. In this borderland the distinction between the species is vague, and I am unable to decide upon such forms as pl. 38, figs. 20. Fig. 21 of the same plate I consider a *stewartii*, as no *vulpina* is dextral. When the *olivacea* pattern occurs in colonies of such shells, one may safely pronounce them *vulpina*.

In the northeastern head of Nuuanu valley there is a local form of *vulpina* which has been described by Mr. Baldwin as *A. ernestina*. It is rather large and capacious typically (pl. 39, figs. 3 to 6), but varies so much in size and width that no definite line can be drawn. Fig. 4 is one of Mr. Baldwin's figured cotypes. Figs. 3, 3*a* are from one tree (*Dracæna*), taken by Dr. Cooke. The shell is either yellow, deepening to

yellow ocher on the last part, and fading on the spire, or this ground may be decorated with bands and lines of chestnut brown or blackish-chestnut; the banded form being the pattern of Mr. Baldwin's types. It is found only in hybrid colonies of the two patterns, plain yellow and banded, usually both on the same tree.

Length 21, diam. 12.4 mm.; 6⅓ whorls (cotype of *ernestina*).

Length 19.7, diam. 11 mm.; 6 whorls (topotype).

On the floor of Nuuanu there is a smaller, narrower race with the coloration of *ernestina*. Pl. 39, figs. 7 to 7*c* were taken by Dr. Cooke on one small *lehua* shrub in the middle of upper Nuuanu near the old road to the Pali. Three are banded, one on an ocher yellow ground, the others straw and primrose yellow. One specimen is bandless, of a "turtle green" tint,—an *olivacea* admixture.

Further west, in an isolated clump of nearly dead lehua trees in the valley near the end of the ridge defining Hillebrand's Glen, Mr. Richard A. Cooke collected a large series, pl. 39, figs. 8 to 8*e*, varying from elongate to conic in shape. The longer shells have *ernestina* pattern on light or dark ground. The shorter ones are straw yellow fading to buff above, base chestnut, the colors either sharply defined (fig. 8*b*) or blended (fig. 8*c*); yellow with a dark sutural line (fig. 8*a*), or amber or straw yellow, uniform or with some white bands (fig. 8).

In a lot taken in the same place by Dr. C. M. Cooke there are 22 of the uniform yellow pattern, 12 of the patterns of figs. 8*b*, 8*c*, 1 *ernestina* pattern. In a lot of 7 individuals from one tree, all of these patterns occur, four of the pattern of figs. 8*b*, *c*, but with a dark sutural line, one each of the other patterns.

The *olivacea* pattern without chestnut bands occurs in Glen Ada, on the southern side of Nuuanu (pl. 39, figs. 11 to 11*c*, coll. by Pilsbry) the color varies from amber yellow to paris green or various blends, yellow ocher passing into green towards the suture and base, or ocher with a few green lines. The summit is buff, and there are no brown bands. This is a well-known form, back to the time of Gulick.

Length 20, diam. 11.5 mm.; 6 whorls.

Length 20.3, diam. 10.6 mm.; 6¼ whorls.

There is also a stunted valley form of this race. A lot pl. 39, figs. 9 to 9*c*, from the floor of Nuuanu, taken by Mr. R. A. Cooke in an isolated group of two or three lehua trees, near the southern side of the valley, has no *ernestina* pattern. The shells are wax yellow, the same shading below into tawny (fig. 9*c*) or very rarely the dark typical *vulpina* pattern like pl. 39, fig. 1, or streaked with green on a nearly white or citron ground (figs. 9, 9*b*). There are often a few faint green spiral lines, or a very dilute brown sutural line. They have the small size of other lots from the floor of the valley, length 13 to 17.3 mm. It was abundant, as about a hundred specimens were taken by Dr. C. M. and R. A. Cooke.

Somewhere on the southern ridge Dr. Cooke collected specimens like pl. 39, f. 8*b*, but with a sutural band. Also a small form with the base olive, the rest white, embryonic whorls ochraceous or with a wide ochraceous band. The typical *castanea* pattern was taken by Mr. Gulick on the Pauoa side of Nuuanu (pl. 39, fig. 2), exact locality not known to me.

Northwestern ridge of Nuuanu.—Hillebrand's Glen, (pl. 39, figs. 12 to 12*d*, coll. by R. A. Cooke), in a dark and humid locality on the east side, is probably at the eastern limit of the *longispira* pattern. Some specimens are scarcely distinguishable from the yellow *ernestina* pattern, uniform or with chestnut base; others have the green *olivacea* pattern. The *longispira* pattern is usually pale yellow with green or green and brown lines (figs. 12*c, d.*). This colony is therefore a hybrid of *vulpina, olivacea* and *longispira.*

On the northern ridge of Nuuanu there are other colonies having the same and other patterns in varying proportions, such as pl. 39, figs. 13 to 13*f*; pl. 39, figs. 14, 14*a*. Also pl. 39, figs. 10, 10*a*, from a lateral ravine of northern Nuuanu, patterns of the *virens-longispira* group, but reminiscent of *castanea.* Others specimens from the main northern ridge, coll. by Dr. Cooke, are similar to the yellow form of *ernestina.*

"Nuuanu on the Kalihi side" is the locality of several lots of *olivacea* in the Gulick collection. The shells are like pl.

39, fig. 12*b*. Also *virens* patterns, the same green color with a dark sutural band (fig. 14), or yellow, like fig. 13*b*, or like fig. 13.

It is these lots of which a few are figured in pl. 39, figs. 10, 10*a*, 12 to 14*a*, which connect the *vulpina, ernestina, virens* and *longispira* so inextricably that I do not see the way clear to recognize more than one species in the series.

The typical form of Reeve's *A. olivacea* occurs on the summit of the northwestern ridge of Nuuanu. His figure is copied photographically in pl. 40, fig. 3. The original description follows: "Shell oblong-conical, sinistral, whorls convex, thinly margined round the upper part, columella with a twisted plait. Dark olive-green, encircled with rather obscure brownish lines, columella and interior of the aperture white.

"The rich dark olive coloring of this species leaves off suddenly in an abrupt line at the aperture and the remainder of the body-whorl [parietal wall] is of an orange-fawn tint, like a shell denuded to that extent of epidermis. Hab. ——?" (*Reeve*).

I take *olivacea* to include *A. prasina* Reeve, as the colors intergrade. In fact, typical *olivacea* looks to me like a *prasina* which was *cleaned with hot water.* All I found were of purer green color. However this may be, there are specimens in coll. C. M. Cooke which agree excellently with Reeve's figure and description, from the main northern ridge of Nuuanu. Two are figured, pl. 40, figs. 4, 4a. The shell is indistinctly streaked with brownish olive on a yellowish olive ground, and has rather indistinct spiral lines of the darker shade. There is usually a dark brown line or narrow band below the suture. The embryonic whorls are dirty buff, and the next whorl rather brown than olive. Length 22.5, diam. 11.7 or smaller.

On Waolani Peak (pl. 40, figs. 5 to 5*b*, coll. by Pilsbry) the real *prasina* form occurs. The last whorl is grass green (but varying in shade from a deeper to a more yellowish green), summit very pale buff, and the parietal wall is yellow ocher. The columellar fold is white. This dark green *olivacea*

pattern is found with similar shells having a dark sutural border, and pale mauve columellar fold, the *virens* pattern. A few shells have some darker green spirals on the last whorl, suggesting *longispira* (fig. 5*b*).

Lower, towards the head of Waolani valley the color becomes paler (pl. 40, fig. 5*c*) the general tone olive-yellow, varying toward green or yellow ocher in different specimens; sometimes with a few green spiral lines; the sutural border is often paler, and the spire partly white.

Kalihi valley. A fine series in coll. L. A. Thurston, from the southeastern branch above the waterfall, contains deep and light green *olivacea,* deep chestnut and yellow forms of *virens,* and the *longispira* pattern. It is a hybrid colony.

Kalihi valley is also the locality of Mr. Gulick's *A. cucumis.* It is a *slightly roughened* form of *olivacea* and *virens.* The color is olive with light yellowish olive streaks, colonial buff with streaks of honey yellow, or ochraceous buff with blended chestnut streaks. There is often a dark sutural line, as in *virens,* but in a third of the lot the ground-color extends to the suture. There is rarely a pale peripheral line or narrow band. The shape varies from ovate-conic to somewhat pyramidal. There is a slight rim or thickening within the lip. All the specimens seen are sinistral. I imagine that the slight corrugation is due to unfavorable (dry) station of the individual colony, and probably not a racial character. Two of the original lot are figured, pl. 40, figs. 6, 6*a*.

Kahauiki. A hybrid segregating into *virens, longispira* and *suturalis* patterns is prevalent. There are also *longispira-analoga* hybrids, and shells suffused and streaked with chestnut. These patterns are shown in pl. 40, figs. 7 to 7*c*, ridge running up from Fort Shafter; figs. 8, 9, central ridge; figs. 10 to 10*d*, western ridge; all collected by Mr. Irwin Spalding. Some from the western ridge also have the pattern of pl. 40, fig. 8.

A special Kahauiki pattern is shown in pl. 40, fig. 9, central ridge of Kahauiki. The shell is yellow, green or chestnut, with a broad chestnut band below the suture. This may be called the *suturalis pattern.* It occurs in a nearly pure

colony on the central ridge. Out of about 300 shells in Mr. Spalding's no. 666, two show bands like *longispira* and two have a brown band above the periphery in addition to the sutural band, which is present in every specimen.

Elsewhere the *suturalis* pattern has been seen only from the Western ridge of Kahauiki, where a few occur in the hybrid colony of that ridge, probably having spread thither from the vigorous colony of the central ridge. One is shown in pl. 40, fig. 10*a*.

An individual fluctuation having a very unusual *analoga* pattern, from the Bishop Museum collection, is figured on pl. 40, fig. 10*e*, dark above, with faintly yellow base. A very similar color-form has been found by Mr. Theodore Cooke in Nuuanu valley on the east side.

Kahauiki forms the eastern limit of dextral shells of the *vulpina* series. The western *analoga* pattern also finds here its eastern limit, at least in the typical development of the pattern.

Moanalua valley has forms resembling those of central Halawa and of the western ridge of Nuuanu, such as the forms shown in pl. 39, figs. 12, 13 and pl. 40, fig. 5*b*, 5*c* (*olivacea*); also *longispira* pattern (pl. 40, figs. 11, 11*a*), *analoga* pattern (pl. 40, fig. 11*b*) and various others (pl. 40, figs. 11*c*, *d*, *e*.). Dextral specimens are rare. All of the above from a lateral ravine near the top of the southern ridge of the valley, collected by Dr. Cooke (pl. 40, figs. 11 to 11*e*).

In the northern valley of Moanalua, near the head, there is a large colony of quite small shells, length 14 to 17 mm. The chief constituent is *virens* of many shades, but the *analoga* pattern appears occasionally, and rarely the *longispira* pattern (pl. 40, figs. 12, 12*a*, coll. by Irwin Spalding; fig. 12*b*, coll. by Dr. Cooke); also shells resembling figs. 7, 7*c*, 15*a* in coloration. This somewhat dwarfed race is comparable to the forms from the bottom of upper Nuuanu. *A. lorata* from the same place is also dwarfed. Large series of these diminutive shells in the collections of Spalding, Cooke and Thurston show that whatever factor it is in the valley-floor environment which causes diminution of size, does not affect the productivity of the snails.

Halawa valley is type locality of *A. analoga* Gulick in which the shell is two or several banded with deep brown, and *A. longispira* Smith, which has green and brown spiral lines typically, but is never gametically pure, as many other patterns occur in the colonies. There are blends between the *analoga* and *longispira* patterns. There are also specimens referred by Mr. Gulick to *fuscolineata* Smith, but which seem to me to be split-banded individuals of *analoga*. A selection from the Gulick series is figured, pl. 40, figs. 15 to 15*d*, *analoga*, and pl. 41, figs. 5 to 5*g*, *longispira*. A peculiar *analoga* with the *fuscolineata* pattern from the western valley of Halawa is shown in pl. 40, fig. 13, coll. by Spalding.

In the middle fork of Halawa Mr. Thaanum obtained a fine set of *virens* (pl. 40, figs. 14, 14*a*), pure except for variations in the ground-color, which may be apricot yellow or olive, as in figs. 14, 14*a*, or a deep green, like pl. 40, fig. 10. All are sinistral.

Aeia. The prevalent variety is a fine form of *virens* similar to the Halawa lot described above. The color varies from chestnut or olive (like pl. 40, figs. 14, 14*a*, Halawa) to blackish green(pl. 41, fig. 6, Aeia). The summit of green individuals is frequently marked with chestnut on the first neanic whorl, sometimes on the embryonic whorls also. Occasionally there are two dark bands, showing some tincture of *analoga* blood; and in some colonies rare specimens have the *longispira* pattern. All are sinistral.

In the Cooke collection there are a few shells similar to the dwarf race of upper Moanalua, the color chestnut below, paler upwards.

Waimalu valley. Yellow and chestnut forms of *virens* with the usual sutural band are in Mr. Spalding's collection. All sinistral.

Waiau. Mr. Spalding found green *virens* patterns, together with *longispira* pattern, all *dextral.*

Waimano. Dr. Cooke collected green *virens, olivacea* and a form (pl. 41, fig. 7) resembling *colorata,* except that it has no dark sutural band.

Manana. On the western ridge Mr. Wilder collected green

virens, similar to those of Halawa and Aeia. This is the extreme western limit of the species so far as I know.

Varieties of A. vulpina from the northern or Koolau side of the mountains. The valleys on this side are very short, formed by short butresses, and heading up in precipices often quite as abrupt as the Nuuanu pali, and mainly higher. The ridge can be attained from the northern side in very few places in this part of the range. The snail colonies, chiefly on the lower, less precipitous slopes where trees find foothold around the valley heads, are therefore in a measure isolated from the forests on top and southward. I have seen considerable numbers of these Koolau snails, but all from collections made by Newcomb and Gulick. The present status of the colonies is not known to me.

18*a*. A. VULPINA COLORATA Reeve. Pl. 41, figs. 8 to 8*e*.

"Shell oblong-conical, dextral, whorls flatly convex, columella with a twisted plait, aperture small; yellow, encircled with a very broad green band, sutures black-brown, columella light pink. Sandwich Islands" (*Reeve*).

The last whorl is apricot yellow or lighter above, ochraceous-orange below a wide girdle of grass green or parrot green, which encircles it above the periphery. Rarely the green band is wanting. Other shells are darkened by a suffusion and streaking of chestnut with or without an olive girdle. The sutural band of deep chestnut is invariable in a large lot beebefore us, collected by Gulick. Out of 59 specimens in coll. A. N. S. P., 27 are dextral.

Length 20, diam. 10.5; 6 whorls.

Length 18, diam. 10.3 mm.

Length 17, diam. 9 mm.

Ahuimanu (Gulick); a *colorata* × *virens* form in Kahaluu (Gulick).

Achatinella colorata REEVE, Conch. Icon. vi, pl. 3, f. 18, April, 1850.—PFR., Monographia iii, 461.—*Achatinella consanguinea* SMITH, P. Z. S. 1873, p. 73, pl. 9, f. 3.—*Achatinella ustulata* NEWCOMB MS., according to Pfeiffer, Monogr. vi, p. 172, no description.

In one Gulick lot from Ahuimanu there are transitional specimens between *colorata* and the *virens* pattern, both green and chestnut, similar to pl. 39, figs. 13, 14. These shells are like those from Kahaluu, noticed below. Another lot having the shell banded with deep brown, sometimes with a green band above the brown, was segregated by Mr. Gulick (pl. 41, fig. 8*e*), also from Ahuimanu.

A series collected by Mr. Gulick in Kahaluu (a short distance northwest of Ahuimanu and separated therefrom by a short spur), contains ill-defined *colorata*, the green band indistinct or diffuse, together with green, yellowish-green and chestnut shells similar to pl. 39, figs. 12*b*, 13 and 14. Most of this lot are not distinguishable from *virens* patterns of the Kona side of the range. The colony is apparently a *colorata-virens* mixture. All of them are sinistral.

Kahaluu is as far west as any *Achatinellastrum* of the eastern or *vulpina* group has been traced on the northern side of the mountains.

Mr. Baldwin gives *Kalihi* as a locality for *colorata*, but he must have had some unusual color-form of *vulpina*, or perhaps he was misinformed.

A lot of about 20 specimens of *longispira* in the Gulick collections is labelled "Ahuimanu?" on the rather dubious authority of Mr. Frick. Probably incorrect.

I have never seen *colorata* from the Kona side of the range. Some specimens of *olivacea* from Moanalua (pl. 40, fig. 11*e*) and from Waimano (pl. 41, fig. 7) have a broad green band above, but they lack the dark sutural band of *colorata*. There are also occasional specimens of the *longispira* pattern which resemble *colorata*.

A. consanguinea Smith intergrades completely with the dusky forms of *colorata*. Probably Mr. Gulick selected the specimens out of his lot of *colorata*. The original description follows.

A. consanguinea E. A. Smith. Pl. 41, figs. 9, 9*a*, specimens from the original lot. "Shell sinistral (sometimes dextral) imperforate, glossy, striated with oblique growth-lines and under a lens transversely, and very delicately, variously

streaked with olivaceous and greenish-ashen; lower half of the last whorl chestnut, streaked with the above-mentioned colors. Suture distinctly margined with dark brown. Whorls 6½, convex, the first 3½ ruddy. Aperture white; peristome brown-tinted within and edged with white; columellar fold strong, roseate. Length 18, diam. 10 mm.

"Var.: shell indistinctly zoned spirally with olivaceous." (*Smith*).

"Ahuimanu, Island of Oahu, chiefly on leaves of the kii.

"This species passes into *A. colorata* Reeve, which is also found in Ahuimanu. It differs from *A. colorata* in the same manner and proportion as *A. adusta* Reeve differs from *A. producta* Reeve. About one-third of the specimens are dextral" (*Gulick*).

18*b*. A. VULPINA TRICOLOR Smith. Pl. 37, figs. 10, 11, 11*a*, 11*b*.

"Shell sinistral, ovate-subconic, imperforate, glossy, very finely striated with oblique growth-lines and transverse striæ, white, whorls encircled in the middle with a broad yellowish-olivaceous zone and towards the base streaked with green; suture distinctly margined with deep brown; whorls 6½, convex, the first two or three white or reddish; aperture white; peristome thin, lightly bordered within; columellar fold strong, roseate. Length 20, diam. 10½ mm.

"Var. *a*. Shell white, girt about the middle with one olivaceous zone.

"Var. *b*. Shell yellowish, encircled with a very broad basal zone of chestnut." (*Smith*).

Oahu: Ioleka, in Heeia (Gulick).

Achatinella tricolor Smith, P. Z. S. 1873, p. 76, pl. 9, f. 6.

In form and color it is intermediate between *A. colorata* Rv. and *A. varia* Gk. (*Smith*).

A. c. tricolor is very closely related to *colorata*, which occurs westward, on the other side of the Heeia ridge. As in *colorata*, there is always a narrow brown sutural band or line. Typically the ground-color is white or nearly so above the periphery, citron-green or light yellowish olive below it, with a broad cuticular band of hazel or cinnamon-brown above the periphery, which is marked with a line of the whitish ground,

as in fig. 11*a*. Very often, however, the whole base is hazel or chestnut, and the ground yellowish above. The band may be a good deal widened, as in fig. 11*b*, or much reduced. In one shell it is split (fig. 10). All the specimens seen are sinistral.

The figures and the above notes are from the type and paratype lots in coll. Boston Society and Academy. I have not studied any recently collected specimens.

The original descriptions of forms referred to *A. vulpina* here follow.

Achatinella prasinus Reeve. "Shell oblong-conical, sinistral, whorls convex, obliquely, somewhat rudely impressly striate, columella short, twisted-plaited; very dark green, encircled with obscure dark lines, white at the apex, columella white. Hab. ——?" (*Reeve*).

This is the very dark green form of *olivacea*. Some specimens from Newcomb are noticeably roughened, like *cucumis* Gul. I assume that they were from an unfavorable station.

Achatinella adusta. (Pl. 40, fig. 2, reproduction of original figure). "Shell acuminately oblong, somewhat turrited, sinistral; whorls rounded; columella short, callous, toothed. Dark chestnut, darker towards the base, with a spiral black band beneath the sutures; columella pinkish. Habitat ——?" (*Reeve*).

A. cucumis Gulick. (Pl. 40, figs. 6, 6*a*, Gulick coll.). "Shell sinistral, imperforate, acuminately oblong, solid, shining, striated, green; apex rather obtuse; spire turreted; suture margined, impressed; whorls 6, convex; columellar fold central, white, moderately developed. Aperture oblique, sinuately oval, white within; peristome thickened within, with external margin unreflected, arcuate, acute; columellar margin dilated, adnate; parietal margin wanting. Length 19, breadth 9⅔ mm.; length of body-whorl 13 mm. Average weight 5.2 grains.

"Var. *b*. Of a burnt yellow color.

"Var. *c*. With one or more obscure brownish bands." (*Gulick*).

Oahu: Kalihi, on trees (Gulick). Kalihi to Moanalua (Baldwin).

Achatinella analoga Gulick. "Shell sinistral, imperforate, oblong, conic, solid, shining, finely striated, green, yellow or white, with three black spiral bands, one sutural, one entering the aperture, the other revolving above the suture; apex obtuse; spire turreted; suture margined, moderately impressed. Whorls 6, convex. Columellar fold central, brown or white, moderately developed. Aperture oblique, sinuately oval, white within; peristome thickened within, with external margin unreflected, arcuate, acute; columellar margin dilated, adnate; edged with brown; parietal margin wanting. Length 18⅓, breadth 7⅖, length of body-whorl 12 mm. Average weight 4.8 grains" (*Gulick*).

"Var. *a*. Yellowish white.

"Var. *b*. Brown yellow.

"Var. *c*. Green.

"Var. *d*. Green or yellow at the base and white above.

"Var. *e*. With but one or two black bands.

"Var. *f*. With four or five black bands." (*Gulick*).

Oahu: Halawa (Gulick).

Achatinella longispira Smith. "Shell sinistral, elongate-subconic, imperforate, glossy, striated with incremental and very delicate transverse lines, yellow, promiscuously ornamented with (4 to 6) narrow spiral zones of green and brown. Suture distinctly margined with deep brown. Whorls 6½, convex, the first 3½ whitish. Aperture two-fifths the length, white; peristome with the margin acute, bordered within; columellar fold strong, roseate. Length 21, diam. 10 mm." (*Smith*).

"Var. *a*. Shell shorter, ovate-conic. Length 18, diam. 10 mm.

"Var. *b*. Shell yellow, ornamented with green zones." (*Smith*).

"Oahu: Halawa is the metropolis of the species; a few specimens are reported by Mr. Frick to have come from Ahuimanu (*Gulick*).

"This species is most nearly related to *A. analoga* Gk. which is readily distinguished from this by the two black lines upon the periphery of the whorl. The black or dark brown lines of that species belong to the solid substance of the shell, while the green and yellow bands of this species belong to the epidermis. No dextral form of this shell has been found" (*Gulick*).

A. diluta Smith. Pl. 40, fig. 16. "Shell dextral, ovate-subconic, glossy, indistinctly and very minutely striated with incremental and transverse lines; dilute buff-green, encircled

by several obscure, green transverse lines; suture lightly margined; whorls 5½, a little convex; aperture white; peristome thin, lightly thickened within; columellar fold strong, white. Length 18, diam. 9 mm.

"Habitat, the Sandwich Islands. Judging from its affinities, we may believe that it comes from the island of Oahu" (*Achatinella diluta* SMITH, P. Z. S. 1873, p. 74, pl. 9, f. 14.—THWING, Reprint etc., p. 60, "Kalihi").

The photographic copy of Mr. Smith's figure, pl. 40, fig. 16, is a little too dark green. I have not seen the type of *diluta* in the British Museum, but a specimen agreeing very closely with the figure, in Gulick's collection, no. 905, appears to be a dextral form of *olivacea*. The shape and color, with indistinct green bands, may be matched in sinistral shells. In the western part of its range *vulpina* of several patterns has been found dextral, and it seems likely that the two specimens of *diluta* known are merely rare dextral variants of the common *olivacea*. Mr. Gulick has marked his specimen as from "Halawa?", and I imagine that locality is not far wrong.

A. ernestina Baldwin. (Pl. 39, fig. 4, cotype). "Shell sinistral, subperforate, moderately solid, ovately conical; apex subacute; surface shining, obliquely striated with delicate growth lines, under a strong lens exhibiting numerous, very close, and minute decussating striæ; apical whorls smooth, scarcely decussated. Color yellow, lighter above; variously striped with transverse, dark chestnut bands, the more constant being one bordering the suture, one at the periphery, spiral above, and one encircling the base. Whorls 6, narrowly margined above, somewhat convex; suture moderately impressed. Aperture oblique, oval, faintly exhibiting the dark bands of the exterior; peristome acute, somewhat thickened within, slightly expanded, white, the coloring of the exterior bands appearing on the inner edge; columella white, terminating in a prominent, oblique, tortuous fold. Length 21, diam. 12 mm.

"Habitat, Nuuanu Valley, Island of Oahu.

"The animal, when extended in motion, as long as the shell. Mantle light brown, sprinkled with black and margined on the outer edge with an interrupted reddish-yellow line. Superior portion of foot light brown, thickly studded with small slate spots; under portion of foot light brown with a slate tinge. Tentacles dark slate." (*Baldwin*).

Series of A. casta.

The shells are smaller than most of the *vulpina* group, and often more slender; they are never green. Species of this series inhabit ridges from Mt. Tantalus to Helemano.

19. A. BELLULA E. A. Smith. Pl. 41, figs. 10 to 10*d*; pl. 48, figs. 1 to 18.

"Shell dextral, long-subconic, imperforate, glossy, very lightly striate with lines of growth, dilute chestnut (the spire paler) streaked with darker, and encircled with a few obsolete lines of a somewhat chestnut color, and a nearly black zone (sometimes wanting) below the periphery. Whorls 6½, a little convex; suture lightly bordered with chestnut. Aperture short, ⅖ of the length, white inside; peristome with the margin thin, slightly thickened within. Columellar fold rather strong, purple. Length 20, diam. 10 mm.

"Habitat, Sandwich Islands. Somewhat of the form of *johnsoni* Newc., but the whorls are less tumid, especially the last, and the painting is different" (*Smith*).

Oahu: Pauoa slope of Tantalus and the main ridge at head of Manoa, northwest to the Kalihi-Kahauiki ridge; only high on the ridges, chiefly on leaves of lehua, Straussia and guava.

Achatinella bellula SMITH, P. Z. S. 1873, p. 77, pl. 9, f. 8.—THWING, Orig. Descript., Occ. Papers B. P. B. Mus. iii, p. 56, pl. 1, f. 15.—*A. bellulae* Smith, HARTMAN, Proc. A. N. S. Phila. 1888, p. 32.—*Achatinella multizonata* BALDWIN, Proc. A. N. S. Phila. 1895, p. 215, pl. 10, f. 1, 2.—COOKE, Occasional Papers B. P. B. Mus. ii, pp. 65-76.

A. bellula stands close to *A. casta*, from which it differs by being invariably dextral, with the spire a little stouter, its outlines perceptibly convex. Also it is often larger and more solid. It is the southeastern member of the *casta* series. The locality was unknown to Mr. Smith, but specimens from the head of Pauoa (pl. 48, fig. 1, collected by C. M. Cooke) agree perfectly with the figured type, and that place may be considered the type locality. It is most abundant on the ridges of Manoa, Pauoa and Nuuanu valleys. The color-forms from Pauoa are further illustrated in pl. 48, figs. 1*a*, 2; pl. 41, figs.

10 to 10*d*. The ground varies from white or maize yellow to burnt sienna with chestnut streaks; a sutural band is always present, though often weak, and about one-third of the shells have nearly black bands below and above the periphery, sometimes also around the columella. The upper band is often reduced to a line, or pair of lines, frequently absent. The many-banded forms of Nuuanu are wanting or very rare in Pauoa. Similar forms extend up the Pauoa side of Mt. Tantalus—the eastern limit of the species. Hon. L. A. Thurston has taken it on the Manoa-Koolau ridge, its eastern limit on the main mountain axis. It does not pass Mt. Olympus.

In the head of Nuuanu valley similar forms occur, also with patterns shown in pl. 48, figs. 3, 4, coll. by Dr. Cooke. Other forms are figured from Waolani Peak and towards the head of Waolani valley (pl. 48, figs. 13 to 16, coll. by H. A. P.).

A series from top of ridge of a northern lateral valley of Kalihi shows the usual patterns of Pauoa, etc., also a few shells of a rare pattern, pl. 48, figs. 17, 18.

Near the head of Moanalua the typical pattern was taken by Dr. Cooke. This was probably on the eastern ridge, as the shell is not found low in Moanalua.

On the ridges extending into Nuuanu from the northwestern bounding ridge a form occurs, which though intergrading completely with *bellula* yet has a certain racial status by reason of the prevalence of a copiously banded pattern. This race has been defined by Mr. Baldwin as follows:

A. bellula multizonata Baldwin. Pl. 48, figs. 5 to 12.

"Shell dextral, imperforate, moderately solid, elongately conical, apex subacute, surface shining, striated with fine lines of growth, under a strong lens showing very numerous, extremely minute decussating striæ; apical whorls smooth, scarcely decussated. Color white, variously striped with numerous dark brown lines and bands, some on the base and others spiral. Whorls 6, lightly marginate above, convex; suture lightly impressed. Aperture oblique, oval, white, the dark bands of the exterior visible within; peristome acute, thickened within, slightly expanded, white, the dark lines of the exterior marked on the inner edge; columella purplish

brown, terminating in a strong, oblique, tortuous fold. Length 18, diam. 10 mm. Nuuanu Valley.

"Animal, when extended in motion, longer than the shell. Mantle brown, lighter on the outer edge. Foot above and below light brown; posterior portion tapering. Tentacles long and slender; these, with the head above, slate color." (*Baldwin*).

"A great variety of transition forms occur between this species and *A. bellula* Smith, which is found on the neighboring mountain ridges of Nuuanu Valley, and is a much larger shell. The animals of the two extremes are specifically different. The mantle of the latter is black, whereas that of the former is brown, and that of the intermediate forms varies from black to brown." (*Baldwin*).

Specimens of the type lot are figured, pl. 48, figs. 5, 6.

Dr. C. Montague Cooke has published a detailed study of *multizonata* from which the following extracts are quoted: "Nuuanu valley has a north-easterly trend. The sides are more or less precipitous and rise from a few hundred to more than two thousand feet above the bed of the valley. The sides are covered by a low dense mass of trees, shrubs, ferns and creepers. Extending into the valley, at about right angles to the sides, are numerous sub-ridges. The upper portions of these sub-ridges and of the valleys between them are also overgrown with a dense mass of vegetation. The lower portions and also the bed of the main valley are covered with the introduced 'Hilo grass' (*Paspalum conjugatum*) with here and there clumps or isolated individuals of lehua (*Metrosideros polymorpha*), Straussia, guava (*Psidium guayava*), etc. There are about twenty-three of these sub-ridges, which are more or less parallel to one another. In some cases the foot of a sub-ridge expands into a more or less undulating slope. In numbering these sub-ridges the numbers begin at the head of the valley.

"*A. multizonata* is found on all the upper 17 sub-ridges, a district of about a mile in length, and from 100 to 400 yards in breadth. There are no permanent streams in any of the valleys between these sub-ridges. Two of these valleys usually

have a little flowing water. The valley between sub-ridges XIV and XV serves as a boundary to several of the color-varieties. That between XVII and XVIII serves as a boundary to the whole species. None of the localities are more than 150 yards in diameter. *A. multizonata* is found in more or less open localities. Specimens are seldom found where there is a dense vegetation, the limit being at the thick growths of the 'stag-horn fern' (*Gleichenia dichotoma*) and ieie (*Freycinetia arnotti*). The elevation at which it is found is from about 1000 ft. to about 1400 ft. Of the shells found, 95.5 per cent. were on either lehua, Straussia or guava. Lehua represents 53.3 per cent. of the trees on which shells were found, Straussia 9.8 per cent., and guava 29.8 per cent. Of *A. multizonata* 54.6 per cent. were found on lehua, 14.2 per cent. on straussia, and 26.7 per cent. guava. Of the remaining plants *Pœderia fœtida*, representing 1.7 per cent. [of the trees on which shells were found] yielded 1.2 per cent. of the shells; *Kadua*, representing 2.3 per cent., yielded 1.2 per cent.; and all others, about a half a dozen genera, representing 3.1 per cent., yielded 2.1 per cent.

"In all the specimens collected by the writer the mantle varies from a very dark to a light slate color. It is sometimes mottled with light or dark markings. *A. bellula* is not only larger [than *multizonata*] but the shell is more solid and the median whorls less convex. *A. bellula* varies to a much less extent. *A. multizonata* varies from a pure white to a rich mahogany brown, and also through a larger number of striped variations. The apex of the shell also varies. In about half of the color-varieties the apex is white or a very light brown; the rest have the apex striped with a light to a very dark brown band. The color of the apex is nearly constant in each color-variety. In color-variety W, however, slightly more than half the shells have the apex white, the remaining having a banded apex.

"Young, dissected from the uterus of the animal, usually agree in coloration, with the apex of their parent. Several exceptions have been found of shells with a white apex containing a striped young, while only four cases have been found of shells with a striped apex containing white young.

"For convenience the writer has divided this shell into twenty-five color-varieties. Each of these color-varieties is designated by a letter. The letters thus used are A-T and V-Z. A very large number of intermediate specimens occur. Some of these color-varieties have a very restricted range, being found on only three or four of the sub-ridges; others are found over nearly the whole range of the species. These color-varieties fall naturally into seven groups.

"The first of these groups, and also the largest, is made up of the color-varieties A-H. It is easily recognized, as none of the shells are marked with dark bands or lines. The shells vary from white to yellow. The apex is white to light brown; never striped. The columella is usually white, sometimes purple. This group represents about 37 per cent. of *A. multizonata*. Of this group 63 per cent. were found on lehua, about 16 per cent. on Straussia, and 17 per cent. on guava.

"The second of these groups contains the color-varieties I-M. The shells are white to yellow, sometimes marked with brown. All the shells of this group are encircled at the periphery by a dark brown band, or two brown lines. The apex in every case is white or light brown. The columella is usually purple, almost never white. This group is only found from sub-ridges I-XIV. It contains nearly 19 per cent. of the specimens of *A. multizonata*. Of this group 53 per cent. were found upon lehua, 15 per cent. on Straussia, and 24 per cent. on guava; 48 per cent. of this group were found on sub-ridges IX-XIII.

"The third of these groups contains the color-variety N. This color-variety is so distinct from all the other color-varieties that it is thought best to place it in a group by itself. All the specimens came from sub-ridges III-V, 62 per cent. coming from sub-ridge IV. About 40 per cent. were found on lehua, 21 per cent. on Straussia, and 27 per cent. on guava.

"The fourth group contains the color-varieties O-Q. This group is distributed over nearly the whole range of the species. It is absent, however, from sub-ridges IX-XI. The shells of this group are striped with from four to fifteen lines or bands. The apex is striped with a light brown band. The columella

is usually purple; in only a very few cases is the columella white. Of this group 48 per cent. came from sub-ridge XIV; 44 per cent. were found on lehua, 12 per cent. on Straussia, and 43 per cent. on guava.

"The fifth group is made up of color-varieties R-T. The shell is white, variously striped; the apex is white; columella is usually purple. About 60 per cent. were found on lehua, 15 per cent. on straussia, and 19 per cent. on guava. This group is distributed over nearly the whole range of the species; only five specimens were found below sub-ridge XIV.

"The sixth group is made up of the color-varieties V-Y. The shells are variously colored from a rich mahogany brown to a pinkish purple. The apex is usually banded; in some cases it is white. The columella is usually purple. All except two specimens came from sub-ridge XV-XVII; 75 per cent. were found upon lehua. This group comes nearest, in color, to *A. bellula* Smith, but differs in form and size from that species [but was later considered to be *bellula* by Dr. Cooke].

"The seventh group is made up of the color-variety Z. This color-variety agrees with several of the other color-varieties in the markings of the lower whorls, but differs from them in the very dark banded apex. Of this group 96 per cent. were found on sub-ridges I and II; 70 per cent. were found on guava, and 23 per cent. on lehua. . . . . There are seven of the color-varieties of which over 95 per cent. came from two or three consecutive ridges. . . . In this species it can be seen that isolation plays a greater part than environment."

20. A. CASTA Newcomb. Pl. 41, figs. 12 to 16; pl. 49, figs. 1 to 16.

"Shell conically elongate, solid, polished, shining, dextral or sinistral; whorls 6, rounded, margined above; aperture subovate, rather small; lip simple, thickened within; columella short, with a strong plaited brownish tooth. Color white or yellow, with extremely variable transverse bands of black, brown, pink or white, variously arranged. Length 13 twentieths, width 6½ twentieths of an inch. Ewa; its northern limit is the valley below Mouna Rua, and a half dozen ravines south, in the district of Ewa" (*Newcomb*).

Oahu: Waimalu-Waiau ridge to the Waipio district (collections of Spalding, Cooke and A. N. S.).

Achatinella casta Newc., P. Z. S. 1853, p. 134, pl. 22, f. 12; Ann. Lyc. N. H. of N. Y., vi, 325.—Pfr., Monographia iv, 538; vi, 174.—Thwing, Orig. Descriptions, p. 64.—*Eburnella casta* Newc., Hartman, Proc. A. N. S. Phila. 1888, p. 36.—*Achatinella cuneus* Pfr., P. Z. S. 1855, p. 205.—Sykes, Fauna Hawaiiensis p. 323 (mountains behind Ewa, Perkins).—*Achatinella concolor* E. A. Smith, P. Z. S. 1873, p. 75, pl. 9, f. 1.—*Achatinella pygmæa* E. A. Smith, P. Z. S. 1873, p. 75, pl. 9, f. 11.—*Achatinella ligata* E. A. Smith, P. Z. S. 1873, p. 76, pl. 9, f. 13; and var. *a*, fig. 12.—Gulick, Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 8.

A. casta differs from *A. bellula* by being sinistral as a general rule, but eastward there are dextral shells among the sinistral in some places. It has a somewhat different range of color-forms. There is often a dark sutural band or line, but more frequently none. Newcomb's figure, reproduced in pl. 29, fig. 12, is now a rather uncommon color-form, if found at all in recent collections. It is nearly white with a chestnut sutural line and an olive band below the periphery, with several indistinct spiral lines above it. One from Newcomb is illustrated in pl. 49, fig. 1. Others of the same lot have the base yellow, tinged with chestnut, or the last whorl pale yellow, bandless; white; or white with two to four chestnut bands. Perhaps the lot represents several localities, though *casta* colonies are notoriously polychromatic.

Dr. Newcomb apparently included the later-described *bellula* in his conception of *casta*. Indeed the locality given by him applies to *A. bellula* alone, if I am right in identifying his "Mouna Rua" with Moanalua. He says: "Its northern limit is the valley below Mouna Rua, and half a dozen ravines south, in the district of Ewa." It is practically certain however, that Newcomb's figured type came from west of Moanalua; moreover, the ravines south of Moanalua can not properly be said to be in Ewa. Newcomb's specimens look like Waimano or Waiawa shells. Just eastward of the *casta* area is the habitat of *A. juddii*, and still further east, that of *A. bel-*

lula. According to Mr. Thwing, *A. casta* ranges from Halawa to Waipio; but this extension eastward is very doubtful.

Numerous supposed species have been based upon forms of *casta*, but after seeing the great series brought together by Messrs. Spalding, Thurston, Cooke and Thaanum I agree with Dr. Cooke that no sufficient ground exists for admitting them as races. They are, we believe, selected forms out of colonies which in other specimens "run into" other forms of *casta*. The explanation of Mr. Gulick's over-division of *casta* (which lured Mr. Smith into describing so many forms), is found in the fact that there is a marvellous opulence of color-mutation. Very often some special pattern predominates in, or at the height of its development is special to, a certain colony. Working with small series from scattered colonies, the differences are unduly obvious. *A. casta* deserves monographic treatment, with several plates, but this work cannot properly be done except in Honolulu.

Waimano. Pl. 49, figs. 2, 3, 4, 5, coll. by C. M. Cooke, on northern ridge and lateral ridges of the valley. The most abundant pattern is some shade of yellow, more or less passing into brown, with darker lines or bands. There are also a few copiously streaked shells, with two dark bands; two of this pattern being dextral. Others have dark zones which nearly cover the surface. Two shells are deep chestnut with lighter streaks. Other Waimano patterns are shown in pl. 41, figs. figs. 13 to 13*c*, Cooke collection.

One lot contains some specimens which approach *A. c. margaretæ* in coloration, having two tawny bands on a whitish or yellow ground, and a pink columella (pl. 49, fig. 5). The shape and texture are the same as in other patterns of *casta* found with them. Mr. Spalding found the same pattern in the eastern ravines of Waiawa.

Some Waimano shells, such as pl. 49, fig. 4, approach *A. pupukanioe*, but on account of the form of the columella in old shells, I believe that the latter is an entirely distinct species.

Pl. 41, figs. 14-14*b* are from the *A. cookei* ridge, Thaanum.

Waiawa. *A. casta* is found in both division ridges of

Waiawa in many places, and everywhere in colonies of several colors and patterns. Pl. 41, figs. 15, 15*a*, 15*b*, 16; pl. 49, figs. 7, 8, represent specimens collected by Mr. Spalding, part of his no. 1863. The rarest and almost unique patterns figs. 15 to 15*b* still belonging to his collection. Pl. 49, figs. 9 to 15 are specimens collected by Mr. Kuhns and given me by Mr. Thaanum. The darker shells of this lot also being rare patterns. The ground-color is white, shell-pink or yellow, bandless or with two dark zones (brown to almost black), or rarely with many lines. A sutural dark band is often present. The columella is almost always lilac, but rarely white in albino shells. The embryonic whorls are usually white, very rarely having a broad brown band. Length 18, diam. 9.6 mm.

In the western ravines of Waiawa Mr. Spalding found a small form, length 15-16 mm., with the last two whorls yellow, spire ivory yellow indistinctly streaked with cream buff. It is practically identical with the form from Waipio called *A. pygmæa* by Mr. Smith.

The original descriptions of forms now referred to *A. casta* here follow.

"*Achatinella ligata* Sm. [Pl. 24, fig. 21]. Shell dextral (or sinistral), elongate-ovate-subconic, moderately shining, very minutely striated with growth and transverse lines; whitish, more or less streaked with buff-olivaceous, encircled with usually two pale brown zones, one above, the other below the periphery. Whorls 5½, a little convex, suture distinctly margined, girdled with deep brown. Aperture white; peristome slightly edged within, columellar fold strong, roseate. Length 19, diam. 10 mm.

"Var. *a*. Shell more lengthened. Length 21, diam. 9 mm. (pl. 24, fig. 20).

"Var. *b*. Shell white, the last whorl encircled with several narrow yellow zones." (*Smith*).

Oahu: "reported to be from Waimalu." Type in British Museum.

"It has somewhat the aspect of dextral forms of *A. varia* Gk., but is more elongate and cylindrical" (*Smith*).

Achatinella ligata was based upon mainly dextral shells of the pattern of pl. 41, fig. 13*b*. The figures on pl. 24 are

copied from Mr. Smith's, the specimens having been given by Mr. Gulick. *A. ligata* has usually been considered a form of *A. bellula* by Hawaiian conchologists, but the figures and description agree with a form of *casta* from Waimano. A set of four in the Gulick collection, three dextral and one sinistral, seem to me to belong to *casta*. The type lot, from Gulick, was "reported to be from Waimalu," which is further west than *A. bellula* is known, and near the eastern limit of the range of *casta*. It seems that towards its eastern limit *A. casta* approaches *A. bellula* in characters, and is sometimes dextral. *A. ligata* was based upon specimens of this somewhat intermediate form. The dextral form probably occurs too intimately blended with *casta* to be segregated as a subspecies.

"*A. pygmæa* Smith. Pl. 49, fig. 16. Shell sinistral, ovate-conic, glossy, striated with extremely fine growth and transverse lines, yellow. Suture lightly margined. Whorls 5½, convex, the first 3½ white. Aperture white; peristome slightly bordered; columellar fold moderately large, rose. Length 14, diam. 8 mm. Var.: shell whitish, encircled above the periphery with a line, below with a zone of brown. Waipio" (*Smith*).

The type specimen is figured. It measures 14.7 mm. long, 8 wide, and differs from unicolored Waiawa *casta* only in the smaller size. Possibly *pygmæa* can be retained as a varietal name for the small western *casta*, if size proves to be correlated with distribution, which is not likely. Waipio is near the western limit of *A casta*. Mr. Spalding collected a similar small form of *casta* in the western ravines of Waiawa, but it is not quite identical, having the spire noticeably broader. However, the variation from *pygmæa* is not greater than among individuals in other Waiawa colonies.

A. concolor E. A. Smith, [pl. 41, fig. 12, type]. "Shell sinistral, ovate-conic, glossy, striated with growth-lines and transversely, even on the first 3 whorls; yellow (sometimes streaked with dilute brown); suture distinctly margined. Whorls 6, convex, the first 3 whitish. Aperture white; peristome thin, the columellar fold strong, roseate. Length 19, diam. 10 mm. Ewa, Frick." (*Smith.*)

Merely a color-form of *A. casta.* The type specimen is no. 76 Boston Society of Natural History. It has been figured by Smith, and is shown on pl. 41, fig. 12. The last 1½ whorls are streaked with ochraceous-tawny on a light ochraceous-buff ground, which fades to white on the upper whorls. There is a faintly darker line below the suture on the last whorl; columella fold pale lilac. Length 18, diam. 10 mm. This coloration is rare in *casta*, but is a common pattern in *A. bellula*, which differs by being dextral.

Mr. Spalding has found shells in the southeastern ravines of Waiawa (his No. 582) which agree exactly with *concolor* except by being smaller. They occur with a more slender banded form with weak columellar fold (pl. 49, fig. 6) recalling *juncea;* with white specimens becoming light yellow on the last whorl, or with a yellow base; and with various brown-banded and streaked forms.

Achatinella cuneus Pfr. "Shell imperforate, whitish or buff, variously ornamented with narrow brown bands. Spire convexly conic, the apex white, rather acute; suture bordered by a chestnut line. Whorls 6, nearly flat, the last slightly exceeding one-third of the length. Aperture nearly diagonal, semioval, white within; columellar fold moderate, obliquely somewhat twisted; peristome acute, labiate within, columellar margin adnate. Length 18, diam. 8 mm., aperture 8 mm. long, 3½ wide. Oahu, Frick" (*Pfr.*).

A. cuneus has been placed in the synonymy of *A. decipiens* by Dr. Newcomb. Mr. Sykes allows it to stand as a species in *Achatinellastrum.* There appears to be no tangible difference between the description of *cuneus* and *A. casta,* and Dr. Cooke, who examined the type, considers it a color-form of *casta.*

20*a.* A. CASTA MARGARETÆ Pilsbry & Cooke, n. subsp. Pl. 42, figs. 9, 10.

The shell is sinistral, imperforate, thin, ovate-conic, white with two cinnamon bands, the lower usually wider, and both tessellated by the crossing of paler streaks; there is a pale pink band below the suture and a darker one bounding the

columella, the fold of which is lilac. There is also an albino form in the same colony, pure white throughout. Surface glossy, similar to *A. casta*. Whorls convex, the suture margined on the last whorl. Columellar fold spiral, not very prominent. Peristome thin, acute.

Length 14.2, diam. 8.6, aperture 7.2 mm.; 5½ whorls.

Length 14.8, diam. 9, aperture 7 mm.; 5½ whorls.

Oahu: Kolokukahau peak, at the head of Waiau valley on the Waimalu division ridge, elevation 1450 ft. (Irwin Spalding, Margaret and L. A. Thurston). Cotypes in coll. A. N. S. P. and Bishop Mus.; also in the collections of Spalding and Thurston.

Margaret's Achatinella is a thinner, less solid shell than *A. casta*, texture and coloration resembling *A. juncea*, which differs by its lengthened, slender contour. It appears to be closely related to *juncea*, but the habitats of the two are rather widely separated and the forms seem sufficiently distinct. No evidence that it actually intergrades with the polymorphic *A. casta* has been seen in the collections examined, though its color-pattern is much like one of the common *casta* patterns. It is doubtless, like *A. juncea*, of common ancestry with *casta*.

A. c. margaretæ was discovered by Miss Margaret Thurston in March, 1909. "Four visits have resulted in finding it on only three lehua trees." It is a shell of the misty summits.

21. A. JUNCEA Gulick. Pl. 42, figs. 11 to 14.

"Shell sinistral, imperforate, elongately and acuminately ovate, thin, shining, finely striated, snow white; apex somewhat acute; spire convexly turrited; suture margined, well impressed; whorls 6, convex; columella white, with a light twisted fold near the body whorl. Aperture oblique, oval, white within; peristome moderately thickened, with external margin slightly expanded anteriorly, arcuate, acute; columellar margin narrow, adnate; parietal margin very thin.

"Var. *b*. With two or three brown spiral bands" (*Gulick*).

Length 16, diam. 8, length of aperture 7.1 mm. (type specimen).

Oahu: Kalaikoa, Wahiawa [type loc.], and Helemano, on ahakea. (*Gulick*).

Achatinella juncea GUL., Annals of the Lyceum of Nat. Hist. of N. Y. vi, p. 230, pl. 7, f. 49. December, 1856.

A. juncea is a thinner, narrower, more lengthened shell than *A. casta*, with the columellar fold usually weaker. It is narrower than *papyracea*, with different color-patterns. From what I have seen it appears to be distinct from related species.

The specimen figured by Gulick and marked "type" by him (pl. 42, fig. 12) is from Wahiawa. Except for a yellow tint at the edge of the lip it is a pure white shell. Others in his collection have two cinnamon bands, one above, narrower, the other wider and below the periphery (fig. 11); or the upper band may be split, and a dark area surround the columella, the whole base having a faint brown tint. Mr. Spalding found substantially the same forms in Kipapa, Wahiawa; (*a*) white, (*b*) white with bands (of which there may be four, sutural, two wider median, and columellar), the lip edged with vinaceous brown, columellar fold deep vinaceous, and (*c*) streaked with cinnamon on a warm buff ground, fading to white above (pl. 42, figs. 13). The length varies from 13.5 to 17 mm. There is a similar lot in coll. C. M. Cooke, including some quite broad forms, length 13.7, diam. 8 mm. (pl. 42, fig. 14).

Specimens from Helemano are similar to white ones from Wahiawa. I have not seen specimens from Kalaikoa.

At Nichol's camp, Kaukinehua (in the Wahiawa district) Mr. Spalding collected a series of six, 3 streaked and bandless, the others with three bands, of lighter tint than in the Wahiawa lot described above.

SERIES OF A. PAPYRACEA.

This group consists of thin, rather capacious shells of the interior valleys, related to *casta* and its allies. A few species from the Waianae range are about equally related to this group and the next. The species seems not to extend so high as other forms, and none has ever been found on the northern side of the main range. While some forms have plumbeous

or ecru streaks, like the *livida* group, the embryonic whorls never have an ocher-yellow band below the suture, such as occurs in most of the *livida* series. The embryo often has a faintly gray or dusky tip.

22. A. PAPYRACEA Gulick. Pl. 42, figs. 7, 8; pl. 54, figs. 8 to 10, 14, 14*a*.

"Shell sinistral, imperforate, ovate-conic, thin, polished, finely striated, light gray or of leaden ash color, with obscure brown spiral lines; apex subacute; spire convexly conical; suture marginate, impressed; whorls 5½, moderately convex; columellar fold central, usually white, slightly developed and not strongly twisted; aperture oblique, sinuately oval, white or gray within; peristome scarcely thickened, with external margin unreflected, arcuate, acute; columellar margin narrow, adnate; parietal margin wanting. Length 16½, breadth 9⅔, length of body-whorl 12 mm. Of a large specimen, length 19, breadth 10⅖, length of body-whorl 13½ mm. Average weight 2.5 grains.

"Var. *b*, without the brown lines" (*Gulick*).

Oahu: Kalaikoa, Ahonui and Wahiawa, on the hala, *Pandanus odoratissimus*, and other trees (J. T. Gulick). Waipio to Kalaikoa.

Achatinella papyracea GUL., Ann. Lyc. N. H. of N. Y. vi, p. 229, pl. 7, f. 48; December, 1856.

Mr. Gulick's type (pl. 54, fig. 8) was from Kalaikoa, where many of the shells have the spiral lines and bands more numerous and distinct than in those from Wahiawa. The ground-tint is white with light brownish vinaceous streaks (very faint or almost wanting in some shells, deeper in others, —more of a light vinaceous purple). The bands vary in tint, from walnut to snuff-brown or brownish vinaceous. They are irregular in width, shade and distribution, but there is usually a peripheral light zone, and the subsutural band is not emphatic, though usually present. The embryonic whorls are white or buff, but so far as I know they are never bicolored, ochraceous and white, as in the *livida* series. Columellar fold usually *weak*, white. The lip is thin and simple.

The type specimen measures, length 16, diam. 9.7, aperture 7.7 mm., but others of the lot from Kalaikoa, are larger, length 18.1, diam. 10.5 mm.; whorls nearly 6 (pl. 42, fig. 8). Some shells from Kalaikoa are more streaked, with faint bands, as in those from Wahiawa.

Shells from Ahonui, Gulick coll., are streaked as in those of Wahiawa, but in some there are broad white zones cutting the streaks into bands (pl. 42, fig. 7).

In "Wahiawa" (pl. 54, figs. 14, 14*a*, Gulick coll.) and Waikakalaua (pl. 54, fig. 10, coll. by Spalding) the bands are merely indicated by pale spirals which cross the copious streaks, which are of a light Payne's gray or violet plumbeous tint. This pattern also occurs in the more western localities, as noted above. It is constant in a series of about 150 taken by Mr. Spalding in Waikakalaua. Also in a series from "Waipio," Spalding coll.

In a series from Waipio district, recently received from Mr. Thaanum, collected by Mr. Kuhns, the pattern consists of brown linear streaks on a pale Quaker drab ground, white, below the suture and often at the base. This pattern usually disappears rather abruptly on the last whorl or sometimes on the penultimate (pl. 54, figs. 9, 9*a*, 9*b*). There is also a very pale specimen, yellowish at the base, with a chestnut-black band below the periphery, another around the columella. It approaches some forms of *A. juddii*.

Series of A. livida.

23. A. juddii Baldwin. Pl. 49, figs. 17 to 22.

"Shell dextral, imperforate, solid, pyramidally conical, apex obtuse; surface shining, covered with very delicate incremental lines; the nuclear whorls smooth. Color light gray, shading into light chestnut on the apical whorls, the gray more intense under the cuticle; with two black lines, one below and one at the periphery, the latter faint and continued on the spire; between the lines a white band which revolves on the suture to the very tip of the apex. Whorls 6, margined above, slightly convex; suture lightly impressed. Aperture oblique, oval, white, the light gray of the exterior surface

exhibiting a darker shade within; peristome acute, slightly thickened within, a little expanded, columellar margin very slightly reflected, white, the coloring of the exterior dark lines reappearing rather more intense on the inner edge; columella white, terminating in a moderately developed flexuous fold. Length, 15; diam. 9½ mm.'' (*Baldwin*).

Oahu: Halawa (Baldwin); Aiea (Cooke, Spalding); eastern crest of Kalauao valley, and Kalauao-Waimalu ridge (Spalding).

Achatinella juddii Baldwin, Proc. Acad. Nat. Sci. Phila., 1895, p. 216, pl. 10, f. 3, 4.

''No opportunity for an examination of the animal has yet occurred. The shell is typically very distinct from any other known species. The light chestnut band on the apical whorls is a characteristic and invariable feature. The basal portion of the shell sometimes has a yellowish hue. In immature shells the colors are more intense.

''Named in honor of Hon. A. F. Judd, Chief Justice of the Republic of Hawaii, by whose son the shell was discovered.'' (*Baldwin*).

A. juddii was discovered by Mr. Albert F. Judd, the present President of the Bishop Museum Board of Trustees. It is related to *A. papyracea*, a more capacious shell. By the color of its embryo and the gray-streaked pattern it is also related to *A. livida* from which it differs by the more pyramidal shape and various details of coloration. It is rather widely separated from other members of the *papyracea* and the *livida* groups, and seems to be quite distinct from all other species.

Figs. 17, 18 represent two of the type lot. All of the Halawa shells sent by Mr. Baldwin (which are probably from the Halawa-Aiea ridge) have a gray-streaked zone above the periphery, bordered by a blackish or darker gray line below, a white or yellowish subperipheral belt followed by a blackish or dark-gray band, the base being white with faint gray streaks, or straw yellow. The embryonic whorls are bicolored, ochraceous with a white zone above the suture.

In a series from Aiea, collected by Dr. Cooke on lehua trees at top of ridge, the same pattern predominates; but there are

also specimens with the two bands near the periphery and no other markings (fig. 21), and others without bands, white above, the base more or less extensively yellow, embryo colored like the typical pattern (fig. 22).

On the Kalauao-Waimalu division ridge Messrs. Spalding and Kuhns found the typical pattern, together with specimens lacking dark bands, fig. 19; and others having several accessory black bands, fig. 20, coll. by Spalding. There is also in Mr. Spalding's collection a single specimen with black base and a broad black band above the periphery. Also a few others having a small black basal area.

Very few specimens from any locality lack the brown or ochraceous zone at the summit; probably all young shells show it, though on rare adults it may disappear by fading.

A. juddii is rather difficult to place in the series, as it has affinities with *casta, papyracea* and *livida*, and seems more related to the last two, though its habitat lies between the areas of *bellula* and *casta*.

24. A. LIVIDA Swainson. Pl. 53, figs. 1 to 9.

"Shell reversed, ovate, obtuse, livid brown or greyish; spire thickened; suture with a deep fulvous line. A small reversed species, unbanded, and scarcely exceeding half an inch in length. In form it perfectly resembles the green variety of *Bulimus citrinus*. The three specimens in our museum vary in color from a light olive brown to a livid purple which lies in longitudinal shades, and gradually changes on the spiral whorls to white. Suture marked by a line of deep orange brown. Aperture white, tinged with purple" (*Swainson*).

Oahu: Wahiawa to Kawailoa district.

Achatinella livida SWAINS., Quarterly Journal of Science, Literature and the Arts, iii, 1828, p. 85; Zoological Illustrations iii, p. 108, pl. 108, f. 2.—*Eburnella livida* Swains., Hartman, Proc. A. N. S. Phila., 1888, p. 36.—*Achatinella viridans* Mighels, REEVE, Conch. Icon. pl. 4, f. 25 (not *A. viridans* Mighels) = *A. reevei* C. B. ADAMS, Ann. Lyc. N. H. of N. Y. v, p. 44; Contributions to Conchology No. 8, p. 128 (1850).—

Achatinella emmersoni Newc., P. Z. S. 1853, p. 156, pl. 24, f. 74.—Thwing, Orig. Descriptions, etc., p. 71.—*A. emersonii* Nc., Ann. Lyc. N. H. of N. Y., vi, p. 309.

Specimens collected in Kawailoa in 1854-5 by Mr. Gulick agree perfectly with Swainson's description and figure. In a lot of 23, 14 are dextral. Shells of this lot are figured, pl. 53, figs. 1 to 4. The typical color is dull citrine (of Ridgway's Color Standards, pl. 16) indistinctly streaked with olive-citrine and olive lake; the suture having an ocher, ochraceous-orange or rufous border, usually edged below with pale yellow. The embryonic whorls are very faint yellow fading to white above the suture and at the apex. The suture has a well-impressed margin. The aperture has a white lining and a chocolate band inside the acute white edge. The columellar fold is white and rather strong. Fig. 1 is a typical *livida,* agreeing very closely with Swainson's figure. Length 16, diam. 10 mm.; 5¾ whorls.

In different specimens the hue and shade vary. The general tint may be brownish vinaceous with narrow whitish streaks, or it may be yellowish olive or dark greenish olive. The dark submargin of the lip is inconspicuous in some shells, especially old ones with the lip thickened.

Form *reevei* C. B. Adams, pl. 53, figs. 5 to 9, Kawailoa, Gulick coll.) differs by having no rufous sutural line. The suture is bordered below by a nearly white or pale greenish yellow band, varying in width. Its exact status is not clear to me, since I do not know whether the specimens occurred in colonies of *livida* or always separate. It seems however to have had a wider range eastward than *livida*, as Gulick got it in Kawailoa, Opaeula and Wahiawa. Both *livida* and *reevei* seem to be rare or extinct at the present time. They probably inhabited forests at lower levels than those now existing.

24*a*. A. livida emersonii Newcomb. Pl. 53, figs. 10, 11, 12.

Based upon a light form of *livida*, as Newcomb recognized later, confirmed by Doctor Cooke who examined the type. The original figure is copied, pl. 53, fig. 10. The description follows. "Shell conical, polished, dextral, rather solid; whorls

6, rounded, margined above; suture distinct; aperture subovate; columella short, tuberculate; lip acute, within margined, black; aperture internally pure white; exterior of shell uniform pearly white. Length 11, width 8 twentieths inch. District of Waialua. This shell in its general aspect is the complete counterpart of *A. mighelsiana* of Pfeiffer. The latter species is from Molokai. This is clearly distinct, as may be seen by a cursory examination of the two species'' (*Newc.*).

Evidently an albino form. Most shells of this kind are not pure white. They are white with narrow streaks of very faint flesh color or very pale gray, often with a faint yellow suffusion on the base. Last whorl somewhat flattened laterally, convex below the impressed subsutural line. Aperture white or pale lilac, usually with a dark streak within the margin.

It varies to a form with yellow base; often there is a rufous subsutural line. It is somewhat intermediate between *livida* and *undulata*, but has the shape of *livida*. There is a good series from Wahiawa in coll. Dr. C. M. Cooke (pl. 53, fig. 11) and others from Waialua, from Baldwin (pl. 53, fig. 12). Named in honor of Mr. J. S. Emerson of Honolulu, who began collecting in the time of Newcomb. The name was originally spelled ''*emmersonii*'' by Newcomb, but in his list of 1858 it was corrected to *emersonii*, and placed in the synonymy of *livida*. The ''subspecies'' of *livida* must not be taken too seriously!

24*b*. A. LIVIDA RECTA Newcomb. Pl. 30, figs. 45; pl. 53, figs. 13 to 21.

''Shell usually dextral, solid, pyramidal; whorls 6, but slightly rounded, margined above; suture slightly impressed. Aperture subovate; lip simple, thickened within; columella short, twisting to unite with the inner lip. Color various, usually yellow, plain or with two black bands on the last whorl, one of which is lost in the aperture, the other becomes sutural. The shell above described is peculiar for its solidity and rigid aspect. It possesses none of the graceful curves which give to this genus so much of its beauty. The largest

size yet discovered is given in the measurement. Length 14, diam. 7 twentieths of an inch.'' (*Newc.*)

Oahu: Waialua (Newcomb); Wahiawa (Cooke); Helemano and Kawailoa (Gulick, chiefly sinistral form).

Achatinella recta Newc., P. Z. S. 1853, p. 145, pl. 23, f. 45, 1854.—Pfr. Monogr. iv, 535.—Gulick, Evolution, Racial and Habitudinal p. 41, pl. 2, f. 3 (Kawailoa).—*Achatinella glauca* Gulick, Ann. Lyc. N. H. vi, p. 60, pl. 8, f. 51, 1858.

Doctor Newcomb's figure is reproduced on pl. 30, fig. 45. A topotype from Newcomb, typical in pattern, is before me. There is a broad purplish-brown band at the periphery, another below it, and a very faint band in the middle of the upper surface, cuticle yellow on the last whorl, lighter above. Others of the same lot are bandless, or have a wide zone in place of the two bands, pl. 53, figs. 13, 14, 15. The surface is nearly smooth, under a lens showing light growth-lines and a very faint oblique lineolation. The dark bands color the internal lip-callus, which is thin and inconspicuous. The columellar fold is rather small. As in *A. livida*, an ochraceous band may usually be made out below the suture of the embryonic whorls, but it is often very pale.

The locality ''Nuuanu valley'' given by Mr. Sykes is a mistake. Some other form, perhaps *multizonata*, must have been taken for *recta*.

Except in color, and in being partly dextral, *recta* does not differ materially from *livida*. The classification of *recta* in *Bulimella* with *A. pulcherrima* or *A. byronii* by various authors is not easy to account for, as the lip is quite unlike those forms. A majority of the specimens before me are sinistral, but dextral shells are in the lots from Waialua, Kawailoa and Wahiawa.

Kawailoa. In a lot of 68 taken by Gulick, three are dextral. The ground-color varies from straw yellow to citron yellow. The bands vary from dark chestnut to honey yellow or paler. Usually there are only two bands, one above, the other below the periphery, but in a few there is a sutural band also.

Two bands present, light in 14, dark in 11 shells.

One band (ii) present, light in 32, dark in 7 shells.

Sutural band only, light in 0, dark in 1 shell.

No bands, 3 shells. See pl. 53, figs. 17 to 21.

Helemano. A specimen taken by Gulick has three honey yellow bands.

Wahiawa. A series collected by Dr. Cooke has three blackish chestnut bands on a white or yellow ground, or white above, yellow below the periphery, both dextral and sinistral (pl. 53, fig. 16). Also the form with honey yellow bands, all sinistral.

A. glauca Gulick, pl. 44, figs. 5, 6, 7, seems to me to be merely a dark form of *recta,* hardly worth a name, differing only in the olive lake ground-color. There must however have been a considerable colony of similar shells as Gulick secured a large set. The description follows. "Shell sinistral, rarely dextral, imperforate, acuminately ovate, solid, shining, striated, fawn or lead-colored with two black bands, one entering the aperture; apex somewhat acute, white; spire conic with slightly convex outlines; suture marginate, moderately impressed; whorls 6, convex; columellar fold central, white or pale pink, moderately developed; aperture sinuately oval, white within; peristome thickened within; with external margin unreflected, arcuate, acute, bordered with brown; columellar margin dilated, adnate; parietal margin wanting. Length 17, breadth 9 mm.; length of body-whorl 11⅕ mm. Average weight 3.9 grains.

"Kawailoa, on trees. J. T. G.

"Var. *b.* With a third brown sutural line.

"Var. *c.* With but one black spiral band passing above the suture.

"Var. *d.* With a white band encircling the base between the two black bands; very rare.

"This species bears the same relation to *A. livida* Swains, that *A. recta* Newc. bears to *A. casta* Newc." (*Gulick*).

Fig. 5 represents Gulick's type specimen, no. 51 Boston Society. A large set from the same lot is no. 92,284 A. N. S. P The shell differs from *A. livida* by having two nearly black spiral bands and usually no distinct subsutural band—characters in which it agrees with var. *recta,* from which it differs only in the ground-color. The color of the suture is variable, some shells having an inconspicuous dusky or yellowish border below the suture. One specimen has a pair of wider,

contiguous chestnut bands and a narrower subsutural band of the same color. The ground color is olive lake in the type, but varies in tint. It is nearly wax yellow in the chestnut-banded shell. The lip is often well thickened within and shows dark spots at the ends of the bands. The embryonic shell when unworn shows the characteristic yellow zone of *livida* below the suture, the rest of the whorl being white. This zone changes to brown on the following neanic whorls, but as stated above, fades to yellowish or disappears on the last whorl.

24*c*. A. LIVIDA HERBACEA Gulick. Pl. 44, figs. 1, 2, 3, 4.

"Shell sinistral, sometimes dextral, imperforate, ovate conic, solid, shining, striated, of a dull green color; apex rather obtuse, white; spire conic, suture marginate, moderately impressed; whorls 6, convex; columellar fold central, white, strong; aperture truncately auriform, white within; peristome slightly thickened within; with external margin unreflected, arcuate, acute; columellar margin dilated, adnate; parietal margin very thin. Length 18, breadth 10⅖, length of body-whorl 13 mm. Average weight 4.4 grains.

"Var. *b*. With a black sutural band; columellar fold usually white, sometimes lilac.

"Var. *c*. Yellow, with smoother surface, approaching *A. recta* Newc.

"About a fifth of my specimens are dextral" (*Gulick*).

Oahu: forests between the streams of Waimea and Kawailoa, on the leaves of the pua, ahakea and ohawai (*Lobelia grimesiana*). J. T. Gulick.

Achatinella herbacea GUL., Ann. Lyc. N. H. of N. Y. vi, p. 233, pl. 8, f. 52, Feb., 1858; Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 4.

A darker, *greener* shell than *recta*, also more strongly striate, and very rarely having any bands except the sutural, which is occasionally present. Mr. Gulick's type, pl. 44, fig. 1, is indistinctly streaked with citrine to olive-green on a yellower, pyrite yellow, ground, the narrow, well-defined sutural margin somewhat tinted with chestnut; three apical

whorls white with a pale ochraceous zone below the suture. While very glossy, it is more roughly striate than *livida* or *recta*.

Others of the original lot, (pl. 44, figs. 2, 3, 4, coll. by Gulick), are darker or lighter than the type—medal bronze or oil green to amber yellow of Ridgway's Color Standards. The sutural border may be colored like the rest of the whorl, or there may be a blackish chestnut band; but there is no light zone or band below the suture. One specimen has a pair of chestnut bands near the periphery.

While close to *recta*, it may be practicable to distinguish this form as a local race. I do not know that it has been found since Gulick's time.

25. A. CURTA Newcomb. Plates 45 and 46.

"Shell conical, sinistral, polished; whorls 5, rounded, margined above, the last very ventricose; aperture ovate; lip simple, slightly thickened within; columella short, with an abrupt callous termination; suture but little impressed; color yellow or chestnut, plain or with a black sutural band, rarely with two or more on the last two whorls; columella white or light brown. The rounded whorls and obese appearance of this shell are strikingly characteristic. It is a rare species and extremely limited in its range. Length 12, diam. 8 twentieths of an inch" (*Newc.*).

Oahu: Waialua (Newcomb). Ahonui to Kawailoa, and across the range in Laie.

Achatinella curta NEWCOMB, P. Z. S. 1853, p. 144, pl. 23, f. 43; Ann. Lyc. N. H. of N. Y. vi, 329.—PFR., Monogr. iv, 540; vi, 176.—*Achatinella rhodoraphe* E. A. SMITH, P. Z. S. 1873, p. 74, pl. 9, f. 10.—GULICK, Evolution, Racial and Habitudinal, pl. 41, pl. 2, f. 6 (Wahiawa).—*Achatinella undulata* NEWCOMB, Proc. Boston Soc. N. H. v, p. 218, Sept., 1855; American Journal of Conch. ii, p. 216, pl. 13, f. 15.—PFR., P. Z. S. 1855, p. 208 (Feb. 5, 1856); Monogr. iv, 540.—*Achatinella delta* GULICK, Ann. Lyc. vi, p. 231, pl. 8, f. 50, Feb., 1858; Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 5 (Wahiawa).

Typically distinct from *livida* and *recta* by the shorter spire and the short, swollen, last whorl; also differing in the color-patterns; yet there are forms which one cannot satisfactorily classify. Pl. 45, fig. 1 is a copy of the type figure.

There are three color-forms which have been described as species under the names *curta* (yellow with a chestnut or chestnut-black subsutural band), *rhodoraphe* (yellow with a pale pink subsutural band), and *undulata* (pale ochraceous buff with many irregular tawny stripes and sometimes a blackish peripheral band). There are also a number of other patterns as noted below. The *curta* and *rhodoraphe* patterns often occur in the same colony, and *curta* colonies sometimes contain both *rhodoraphe* and *undulata* if I may judge by Wahaiwa series in the Cooke collection. Chiefly *rhodoraphe* occurs in Ahonui (Gulick coll.), at the eastern limit of the species, and pure *curta* has been taken in Laie, unaccompanied by other patterns. There are some "blends" between these three patterns, but as a general rule, good segregation prevails in hybrid colonies.

Northwestward *curta* is replaced by *dimorpha*, in which the shell is usually more lengthened.

Ahonui (pl. 45, figs. 2, 3, coll. by Gulick). Most of the specimens are yellow with a pink zone below the suture (*rhodoraphe*). The pink zone begins on the last embryonic whorl as an ochraceous band. The largest shell is 17 mm. long. There are also a few shorter shells of typical *curta* form, yellow fading to white at the summit, without a subsutural band.

Wahiawa (pl. 45, figs. 10, 11, 3d gulch of Wahiawa, coll. by Kuhns). Last whorl or two apricot yellow, with a chestnut-black band below the suture, edged below with orange rufous, sometimes followed by whitish. Embryo all white or with a brown hand extending to the apex. The same *curta* pattern is in the Cooke collection from low ridges and valleys of Wahiawa, together with specimens without sutural band, and others with it faint and narrow, the embryonic whorls with an ochraceous band, the body-color varying from yellow to ochraceous tawny. Also *rhodoraphe* like those of Helemano, or without

a pink band (like *A. delta* var. *b.* of Gulick), and various forms of the *undulata* pattern (pl. 45, figs. 4 to 9), from the pattern figured by Newcomb to forms with the streaks almost or entirely wanting, the band remaining. A last vestige of the *undulata* pattern is usually visible in a minute irregularity or mottling of the dark peripheral band in specimens which have otherwise the color of *curta*. There are also tawny-streaked forms without a band, the typical *undulata* pattern.

Helemano. In a small ravine south of Helemano, Mr. Spalding found *curta*, with chestnut sutural band and plain (no. 2274-5 of his coll.). His no. 2268 from Helemano have a yellow base, white above. Gulick found the same form, which he called *A. delta* var. *b.* (pl. 46, figs. 6, 7, 8). Gulick also obtained a large series of typical *rhodoraphe* in Helemano, which he regarded as the metropolis of this form (pl. 46, figs. 1, 2, no. 92210 A. N. S.), associated with specimens like pl. 45, fig. 3. In a gulch west of Helemano Mr. Spalding found *curta* with black and with pink sutural border, and with a light brown subsutural line, in the same colony (pl. 46, figs. 3, 4).

"*Waialua*" is the type locality of *curta* and *undulata*, but just where Newcomb collected in the extensive district which went under his name, I do not know. Perfectly typical *curta* has been taken by Mr. Thaanum on the left side of Poamoho, with specimens without the chestnut sutural band (pl. 45, figs. 12, 13). Mr. D. D. Baldwin obtained typical *undulata* and a pale form perhaps referable to *emersoni* in "Waialua," locality not more exactly given (pl. 45, figs. 14, 15, 16).

In the bottom of gulch east of Opaeula along the stream, Mr. Spalding took *curta* with the sutural band: (*a*) blackish-chestnut, (*b*) varying to tawny, approaching *rhodoraphe*, and (*c*) with brownish vinaceous streaks on a cream-buff ground, suture with a narrow tawny band (pl. 46, fig. 9), also varying to nearly white. Some have more or less olive-yellow suffusion of the base or last whorl. This form approaches *undulata*. There are also white and yellow *curta* without sutural band in this colony, which is related to the streaked form from Kawaiholona.

Opaeula. Gulick found *rhodoraphe*, varying from a wide to a linear sutural border.

On the Opaeula-Kawaiholona division ridge Mr. Spalding found *curta* with a black or purplish sutural band, and a few white ones with yellow tint on at least part of the base.

Kawaiholona. On the eastern spurs Mr. Spalding found faintly streaked *curta-undulata* forms similar to pl. 46, fig. 9. Along the bed of the stream a form was found with the characters of the preceding intensified, intermediate between *curta* and *livida* (pl. 46, fig. 10, coll. by Spalding). It has a rufous or chestnut sutural line, followed by a white band, below which it is streaked with Dutch blue or slate blue on a whitish tint of the same, the base with a yellowish suffusion. There is a slate-purple streak within the white lip-edge, and the columellar fold is white. While the coloration of this colony is much like *livida*, it connects with *curta* through forms found eastward, as noted above. A brown form also occurs in the same colony (no. 1612 of Mr. Spalding's collection).

"*Kawailoa.*" Mr. Gulick found *curta, rhodoraphe* and *undulata* patterns, the latter small, and varying to specimens in which the tawny bands are diffused, producing an ochraceous-tawny shell with indistinct dusky streaks (pl. 46, figs. 20 to 24). Pl. 46, figs. 16-19 are Kawailoa forms from Thaanum.

Kawaiiki. Above and at the Waialua Agricultural Company's intake, Mr. Spalding collected a series of beautiful color-forms, illustrated in pl. 46, figs. 11 to 15. The following color-forms occur. (*a*) Yellow, varying to white with the base faint yellow, apical whorls often ochraceous. (*b*) yellow with a pale tawny sutural line or a chestnut or blackish sutural band, typical *curta* pattern. (*c*) yellow with two or three chestnut-black bands, which may cover most of the surface. (*d*) yellow, with diffuse chestnut streaks and sutural band, or with deep chestnut streaks and sutural and peripheral bands, approaching *undulata*. (*e*) Pale yellow with diffuse serpentine green streaks and a chestnut sutural band, a dark streak within the outer lip; approaching *livida*.

In the collection of Hon. L. A. Thurston there is a good

series of *curta* in several color-forms, which he took in the bottom of Anahulu valley. This is as far west as real *curta* has been found, so far as I know.

Laie. A series of 15 specimens, all of the typical *curta* pattern, was taken by Mr. Spalding. One is figured on pl. 46, fig. 5. This is the only record of *curta* from the north side of the main range, unless we include Gulick's *A. contracta*, which is not really distinguishable from some Wahiawa *undulata* in which the streaks are nearly or quite obsolete. On account of its locality I have left *contracta* with the *dimorpha* group of forms.

The original descriptions of *undulata* and *rhodoraphe* follow.

"*Achatinella undulata.* Shell sinistral or dextral, rather solid, acutely conical, shining, polished; with longitudinal oblique fine striæ; microscopically spirally striate. Whorls 6, rounded and margined above; suture well impressed. Aperture subovate; columella short and plicately twisted; lip acute, thickened within. Color light olive alternating with slightly undulating chestnut lines and bands, rarely marked by transverse black fasciæ. Columella and aperture white. Length 12, width 6 twentieths of an inch. Waialua, Oahu" (*Newc.*).

"*Achatinella rhodoraphe* Sm. Shell sinistral, shortly ovate-conic, imperforate, glossy, striated with growth lines and (under a lens) very fine transverse striæ; yellow, encircled below the suture with a wide zone of pale rose. Whorls 6, convex, the first three white; suture distinctly margined. Aperture white; margin of the peristome acute, bordered within; columellar fold strong, rose (sometimes white). Length 15, diam. 8½. Var.: Shell yellow, suture zoned with chestnut below.

Station: on trees. The metropolis of the species is Helemano, on Oahu. It is also found in Ahonui, Wahiawa, Opaiula and Kawailoa. It is related to *A. livida* Swn. and *A. curta* Nwc., but is easily distinguished from either. This species is always sinistral" (*Smith*).

A. curta delta Gulick. Pl. 45, figs. 17 to 22. "Shell sinistral, imperforate, conic, obliquely truncated at the base, solid, shining, striated, yellow at the base, paler above, with 2 or 3 ash-brown bands; apex rather obtuse, white; spire conic; suture marginate, lightly impressed; whorls 5½, slightly con-

vex; columellar fold central, white, strong; aperture truncately auriform, white within; peristome thickened within; with external margin unreflected, arcuate, acute; columellar margin dilated, adnate, white; parietal margin wanting. Length 16, breadth 10⅔, length of body-whorl 11⅔ mm. Average weight 4.7 grains.

"Var. *b*, without bands. Var. *c*, with one black spiral line. Var. *d*, with two broad black bands." (*Gulick*).

Oahu: Kalaikoa, Ahonui, Wahiawa and Helemano, on trees and shrubs. J. T. Gulick.

"In Wahiawa, which is the metropolis of the species, var. *a* is most abundant; var. *b* is more widely diffused, being occasionally found in each of the above-mentioned localities; vars. *c* and *d* are very rare; the former approaches *A. contracta* Nob., and the latter passes into an unusual variety of *A. emersonii* Newc." (*Gulick*).

A. delta is a connecting form between *reevei* and *curta*, comparable to the streaked form of *curta* from Kawaiholona, and probably not more deserving of a varietal name than that.

Mr. Gulick's type of *delta* is a Wahiawa shell closely agreeing with pl. 45, figs. 20-22, from the same lot, of which over 60 specimens are before me, No. 92,619 A. N. S. The prevailing shape is that of *A. curta*, but it varies to longer shells, like *livida*. The color-forms figured on pl. 45, figs. 17-22 are from one colony.

(*a*) The ground color of the typical form is white above, on the last whorl shading from white at the suture to pinard yellow on the base, the yellow area often much reduced. The sutural margin is white, followed by a band of violet plumbeous, grayish lavender or ecru-drab obliquely streaked with white. Above and below the periphery there are similar bands. Sometimes the lower band is wanting, and the others reduced to lines; and rarely the dark color of the bands extends in streaks over the whole banded portion, much as in *reevei*, or in the rare variety of *curta* from Kawaiholona. (*b*) The other common color-form has a ground of yellow, fading above the periphery to white, or rarely continuous over the whole last whorl. It has no dark bands, or rarely

bands of a faint chamois tint. This form occurs with the typical form (*a*) in Wahiawa, but without it in Ahonui, Helemano and Kalaikoa. It is hardly to be distinguished from bandless *curta,* and approaches very close to *rhodoraphe.*

The fact seems to be that the unicolored form of *delta* (*b*) is a mutation of the *curta-rhodoraphe* stock which has rather a wide distribution, and somewhere in Wahiawa district it formed a hybrid colony with the streaked *livida-curta* stock; pattern (*a*) of the heterogeneous lot called *delta* being the result. Very likely the type colony of *delta* was limited to a small area and is now extinct.

26. A. DIMORPHA Gulick. Pl. 42, figs. 15 to 20; pl. 47.

"Shell sinistral, sometimes dextral, imperforate, turreted, solid, shining, striated, white or yellow with a brown sutural band [see below for bandless and for two- or three-banded patterns]; apex rather obtuse; spire turreted; suture marginate, moderately impressed, dark brown; whorls 6, convex, columellar fold central, white or rose, moderately developed; aperture truncately ellipsoidal, white within; peristome slightly thickened within, with external margin unreflected, arcuate, acute; columellar margin dilated, adnate; parietal margin waiting. Length 18, breadth 9⅖, length of body-whorl 11⅖ mm. Average weight 4 grains. Habitat, Waimea, Pupukea, Waialei and Kahuku, Oahu, J. T. G.! Kaawa, Oahu, J. S. Emerson" (*Gulick*).

Oahu: northwestern ridges from Waimea to Kahuku; Hauula and Kaaawa on the north side.

Achatinella dimorpha GULICK, Ann. Lyc. Nat. Hist. of N. Y. vi, p. 236, pl. 8, f. 56.—*Achatinella albescens* GULICK, t. c., p. 237, pl. 8, f. 57; Evolution, Racial and Habitudinal, p. 41, pl. 2, f. 2 (Pupukea).—*Achatinella zonata* GULICK, t. c., p. 238, pl. 8, f. 58; Evolution, etc., pl. 2, f. 1 (Pupukea).—*Achatinella contracta* GULICK, t. c., p. 239, pl. 8, f. 59. Feb., 1858.

A. dimorpha differs from *A. curta* chiefly by its more graceful lengthened contour, the last whorl being longer, less inflated, and more slowly tapering below, whereas *curta* is

more squat, the last whorl shorter and more obese. Yet the shapes intergrade, *dimorpha* colonies sometimes containing shells exactly like some of the longer specimens of *curta*. The gamut of color-patterns is in part different in the two species. While the distribution of *curta* and *dimorpha* does not overlap, as known at present, there is a long boundary still to be exactly investigated where connecting colonies may confidently be expected. The difficulty of delimiting the *curta* and *dimorpha* territories is therefore likely to increase with enlarging knowledge. It may turn out that my attempt to separate *curta* and *dimorpha* is impracticable in some colonies. Yet here, as in most tree snails, there has been differentiation between forms of the interior slope and those of the Pacific slope west and north.

Three mutations have been named as species: *dimorpha*, yellow, fading to white near the suture, which has a narrow chestnut or blackish band. *Zonata*, ground-color the same or nearly white, with two blackish bands, at and below the periphery, and often a sutural band also. *Albescens*, base yellow, fading upwards, or whole shell nearly white; no bands. The *zonata* and *albescens* forms ordinarily, perhaps always, live in mixed or hybrid colonies; *albescens* and *dimorpha* patterns have also been found together. I do not know that the *dimorpha* form is found living with both of the others, but it probably is. Mr. Gulick, who obtained these forms when they were abundant, assorted his shells and preserved no indication of their association.

The areas of distribution of *zonata* and *albescens* as given by Gulick coincide exactly. He got both in Waimea, Pupukea, Waialea, Kahuku, Hauula and Kaaawa. *Dimorpha* was obtained in the same places except Hauula; but he got few shells in that valley. While in the following account I use these names for convenience in referring to particular patterns, it will be understood that they are not of the nature of subspecies or geographic races, but merely mutations existing in hybrid colonies. While sinistral shells are the rule, there are occasional dextral shells. In Waimea and Pupukea the dextral form is rather abundant.

The *dimorpha* forms were collected in abundance by Gulick and J. S. Emerson in the Fifties. In the last few years they have been taken by Messrs. Spalding, Kuhns and Wilder.

Waimea. Mr. Gulick obtained shells of *zonata, albescens* and *dimorpha* patterns. Some of the *albescens* have two-thirds of the last whorl yellow, with a white line at the periphery, elsewhere white. Others are typical, the yellow fading upwards to white which forms a zone below the suture.

Pupukea. The type specimen of *dimorpha*, no. 56 Boston Soc. coll., from Pupukea, is figured, pl. 47, fig. 1. The last whorl is amber yellow, fading upwards to nearly white near the narrow chestnut sutural band. This band ascends to the summit, but on the embryonic whorls it widens and becomes ochraceous. Surface glossy; aperture and columellar fold white, the latter small. The Gulick collection also contains a good series from Pupukea, comprising (*a*) the three-banded typical *zonata* pattern, both sinistral and dextral; (*b*) shells with white ground or faintly yellow, fading upwards, with a tawny sutural band, the embryonic whorls white or with an ochraceous band, columellar fold white; rarely dextral (fig. 2), and in one shell the bands of *zonata* are faintly indicated. (*c*) *albescens* pattern, the last whorl straw yellow, deeper near the lip, fading upwards, no bands. Probably all of these forms were from one colony.

Mr. Spalding's No. 2187, from the Pupukea side of the Paumalu ridge contains exactly typical *dimorpha*, together with shorter shells indistinguishable from *curta*, the last two whorls yellow, band chesntut; also a form resembling pattern *b* of Gulick's lot, having the shell white, sutural band dark vinaceous, not extending upon the white embryo, the columellar fold lavender. These three patterns are shown in pl. 47, figs. 3, 4, 5.

In the third gulch towards Kahuku from Pupukea Mr. Kuhns collected beautiful 3-banded *zonata* with *albescens* and a pure white form (pl. 47, figs. 6, 7, 8).

Paumalu-Kaunala ridge. A series taken by Mr. Spalding comprises very beautiful *zonata* and *albescens* forms, the latter white to yellow, often with a white peripheral line. Some of

the *zonata* have the bands very broad—an unusual variation (pl. 47, figs. 9 to 13). A lot taken by Kuhns has the same *albescens* forms and the *dimorpha* pattern—short, *curta*-like specimens.

Waialee. Pl. 42, figs. 15, 16; pl. 47, fig. 14. Known to me from abundant series taken by Mr. Gulick. The *albescens* pattern, in white and varying tints of yellow, often with a peripheral white line; columella rarely lilac-tinted. *Zonata* pattern, with white or yellow ground. Also a *dimorpha* pattern, the ground pale yellow or white, sutural line tawny, often very faint, columellar fold white or flesh-tinted. It is similar to pattern *b* from Pupukea.

Kahuku. Gulick reports *zonata, dimorpha* and *albescens.* Some of the *zonata* have lines and oblique streaks between the bands, slightly recalling *formosa* (pl. 47, fig. 15). Very beautiful pale *albescens* have been collected by Kuhns, Thaanum collection (pl. 47, fig. 16), and Mr. Spalding has taken *zonata* in Pahipahialua valley, to the west of Kahuku.

From Kahuku going southeast there are no records of *dimorpha* forms until we reach Kaipapau, and there is another hiatus between Hauula and Kaaawa, which is the limit of the species in this direction, so far as we know. The locality "above Ewa" given by Mr. Sykes for *zonata* must belong to some other species, perhaps *casta.*

Kaipapau. On the lower ridges, just above the kukui tree belt Mr. Spalding took the *zonata* (pl. 47, fig. 17) and *albescens* patterns.

Hauula. The *zonata* and *albescens* forms, taken by Gulick, are before me.

Kaaawa. Mr. Gulick records *dimorpha, albescens, zonata* and *contracta* from this valley, collected by Mr. J. S. Emerson. The abundant series of the *zonata* pattern varies widely, the following forms being represented.

Typical *zonata,* with two blackish bands and a narrower sutural band (pl. 42, fig. 20). Varying to forms with fine lines above the lower band, columella lilac-tinted, or when there is a fourth narrow band around the columella, the fold is purplish-brown (pl. 47, fig. 18).

Sutural band wanting, the other two reduced to lines, either of which is occasionally doubled (pl. 42, fig. 18).

Only one band, the lower (band iii) remaining (pl. 42, fig. 17).

Only the upper band (ii) remaining (pl. 42, fig. 19). Of this pattern there is only one specimen, all of the others being represented by numerous shells.

A. contracta Gulick (pl. 47, figs. 19, 20) is in my opinion only a form of the Kaaawa *zonata*, from which it differs by the shorter contour. Very few specimens were taken. In some of them there are indistinct gray streaks in the ground, which is yellow below, white above the supraperipheral deep chestnut band. This shell reminds one of a similar form of *undulata*. Possibly there has been some infusion of *undulata* blood from across the range. No recent collector has to my knowledge found *contracta* or any of the *dimorpha* forms in Kaaawa, and they are probably extinct in the places where Mr. Emerson collected fifty or sixty years ago.

The original descriptions of *albescens, zonata* and *contracta* follow.

Achatinella albescens. "Shell sinistral, sometimes dextral, imperforate, ovate-conic, solid, shining, striated, white or sometimes yellowish; apex somewhat acute; spire convexly conical; suture marginate, well impressed; whorls 6; somewhat swollen beneath the suture and slightly flattened in the middle; columellar fold central, white, strong; aperture truncately auriform, white within; peristome thickened within, with external margin unreflected, slightly arcuate; columellar margin dilated, adnate, parietal margin wanting. Length 18, breadth 10⅔, length of body-whorl 13 mm. Average weight 4.6 grains. On the leaves of the pua, ahakea and lama. Waimea, Pupukea, Waialei, Kahuku and Hauula, J. T. G.! Kaawa J. S. Emerson! Nearly a third of the specimens from Waimea and Pupukea are dextral, but in Waialei, the metropolis of the species, they are always sinistral." (*Gulick*).

Achatinella zonata. "Shell sinistral, sometimes dextral, imperforate, ovate-conic, solid, shining, striated, white or yellowish with a brown sutural band and two black bands, one entering the aperture; apex somewhat acute; spire conical, with outlines slightly convex; suture marginate, moderately impressed; whorls 6, convex; the last regularly rounded; colu-

mellar fold central, rose or white, moderately developed; aperture semiorbicular, white within; peristome slightly thickened within; with external margin unreflected, arcuate, acute; columellar margin dilated, adnate; parietal margin wanting. Length 16½, breadth 10, length of body-whorls 12⅖ mm. Average weight 4.6 grains. On the leaves of trees. Waimea, Pupukea, Waialei, Kahuku and Hauula J. T. G.! Kaawa, J. S. Emerson! The dextral specimens are for the most part found in Waimea and Pupukea. This and the two preceding species [*albescens* and *dimorpha*] vary much in form and size" (*Gulick*).

Achatinella contracta. Pl. 47, fig. 19, copy of original figure. "Shell sinistral, imperforate, broadly conic, solid, shining, striated, ash or fawn colored with two black bands, one sutural, the other revolving just above the suture on the spire and encircling the base near the periphery of the body-whorl; apex somewhat acute, white with brown suture; spire regularly conic; suture marginate, moderately impressed; whorls 5½, slightly convex, the last large; columellar fold central, white, strong; aperture truncately auriform, white within; peristome thickened within, with external margin unreflected, arcuate, subacute; columellar margin dilated, adnate; parietal margin wanting. Length 13½, breadth 9, length of body-whorl 10 mm. Average weight 4 grains. On trees. Kaawa, J. S. Emerson! Hauula, J. T. G.! The sutural band is sometimes wanting, and some specimens have another band entering the aperture. I have but one specimen from Hauula, which is of the last mentioned variety, and is rather larger than those from Kaawa. It is allied to *A. zonata, nob.*, and *A. undulata* Newc." (*Gulick*).

27. A. CÆSIA Gulick. Pl. 44, figs. 13 to 16.

"Shell sinistral, imperforate, ovate-conic, solid, shining, striated, so streaked with white and fawn brown as to have a gray appearance; apex somewhat acute; spire convexly conic; suture marginate, moderately impressed; whorls 6½, convex; columellar fold central, white, moderately developed; aperture sinuately oval, white within; peristome slightly thickened within; with external margin unreflected, arcuate, acute, edged with brown; columellar margin, dilated, adnate; parietal margin wanting. Length 18⅓, breadth 10⅔, length of body-whorl 13 mm. Average weight 4 grains" (*Gulick*).

"This with *A. concidens* and *A. formosa* nob., which are

found in Waimea, correspond to *A. undulata* Newc., *A. emersoni* Newc., and *A. glauca* nob., found in Kawailoa'' (*Gulick*).

Oahu: Waimea, J. T. Gulick; varieties at Kahuku, Kahana, Hakipuu and Waikane.

Achatinella cæsia Gulick, Ann. Lyc. N. H. of N. Y. vi, p. 234, no. 53, pl. 8, f. 53, Feb., 1858.—*Achatinella concidens* Gul., t. c., p. 234, no. 54, pl. 8, f. 54.—*Achatinella formosa* Gul., t. c., p. 235, no. 55, pl. 8, f. 55.—*Achatinella cognata* Gul., t. c., p. 240, no. 60, pl. 8, f. 60.—*Achatinella scitula* Gul., t. c., p. 241, no. 61, pl. 8, f. 61.—*Achatinella cervina* Gul., t. c., p. 241, no. 62, pl. 8, f. 62.

A. cæsia was the first to be described of a series of shells somewhat larger in size than those of the *dimorpha* series, usually streaked in peculiar hues, and so far as I know, they are always sinistral and never have an ochraceous zone below the suture of the embryonic whorls. These shells were rare in Gulick's time; only *cæsia* and *cognata* were known to him by more than one or very few specimens. To-day they are practically unknown to Hawaiian naturalists. I do not remember seeing any recently collected specimens, and if not actually extinct at the present time the species must be very scarce and local.

The distribution is conspicuously discontinuous — *cæsia, concidens* and *formosa* in Waimea, *cognata* and *scitula* in Hakipuu, and *cervina* in Kahana; yet the presence of another form of the series (*littoralis*) in the sand dunes of Kahuku serves to connect the extremes of its range, and permits the suggestion that it was probably a species of the low-lying forests of former times. This species then probably had the range of *A. dimorpha-albescens-zonata*, but chiefly at lower elevations.

There seem to be several local races, although not so many as Mr. Gulick defined. I would arrange them as follows:

A. cæsia Gulick, including *concidens* and *formosa* Gul. Waimea.

A. c. littoralis P. & C. near Kahuku; extinct.

A. c. cervina Gul. Kahana.

A. c. cognata Gul. Includes *scitula* Gul. Hakipuu and Waikane.

Waimea. The type of *A. cæsia* is figured on pl. 44, fig. 13. The type-specimen is not fully mature, therefore it is rather thin, and reminds one of *A. papyracea.* It is indistinctly streaked with light pinkish cinnamon on a white ground, with a dusky, interrupted peripheral line below which there is a pale line. Suture margined on the last whorl, of the same color as the shell. The embryonic whorls have a faint yellowish tint, the apex being white. Columellar fold white; lip thin, with a pinkish submargin within. The last whorl is slightly compressed laterally, so that it has a somewhat cylindrical contour, though this is not conspicuous. There is a very minute cleft behind the reflected columellar lip in the type and in other immature shells, but in those fully mature it is closed.

Another lot from Gulick, no. 1258 coll. Boston Society (pl. 44, figs. 14, 15, 16) contains several patterns, all with the same slightly cylindric last whorl, but part of them more solid than the type-specimen, being mature. Color as follows.

White, with the faintest yellow tint near the lip, which is acute but slightly thickened within.

White with four brown lines on the last half of the last whorl.

Yellow, with some obscure lines on the base, lip and columella flesh-tinted. Shell smaller, length 16¼, diam. 9.1 mm.

The type and sole specimen of *A. concidens* (pl. 43, fig. 14) is a "dead" shell which has lost its polish by weathering. It is conspicuously streaked with cinnamon, with dashes here and there of darker brown, on a soiled white ground; the streaks interrupted by a white band below the suture, another at and below the periphery, the lower half of the base being also dirty whitish. Embryonic whorls cinnamon-buff, fading to white at the apex. Length 19.7, diam. 11 mm. This shell was no doubt paler, more gray in life. I think it merely a color-form of *cæsia*, not a true race.

The type-specimen of *A. formosa* (pl. 43, fig. 13, No. 55 of type series in Boston Society coll.) is a very beautiful shell. It is solid, more elongate then the type of *cæsia*, but otherwise not dissimilar in contour. The shell is imperforate and

sinistral. The periphery is marked by a white band, with a wide black band below, a narrow one above it. There is a white band below the suture, bordered by an inconspicuous yellowish line. The rest of the upper surface of the last whorl has a light plumbago-gray hue, produced by darker and paler streaks. The base has a blackish band around the columella, and is elsewhere white. The embryonic whorls are white; following whorls of spire have a dark band above and below the suture, which runs in a white band. Columellar fold white and very strong; aperture white within, the acute, beveled lip is colored at the terminations of bands; somewhat thickened. Length 19.5, diam. 10.5, aperture 9 mm.; 6¼ whorls.

A. formosa is merely *concidens* with black bands added. It seems remarkable that Mr. Gulick did not recognize in *cæsia, concidens* and *formosa* merely three stages in the development of pattern, strictly comparable to several other well-known species which have the same sequence of patterns —streaked, streaked and with white spiral bands, and the same with dark bands.

Kahuku: in troughs of sand dunes near the sea, between the road and the shore, about 1½ miles east of Kahuku, pl. 44, figs. 17 to 20, collected by Cooke and Pilsbry. This fossil form is a fairly well-marked subspecies which may be called *A. cæsia littoralis* P. et C. It differs from *cæsia* and its Waimea color-forms by the rougher surface, which is *decidedly more wrinkled* along lines of growth, especially on the last half of the last whorl, and the columellar fold is unusually high on the columella, less prominent than in adult Waimea shells. The shell is thin, *minutely perforate,* varying in shape as figured, and marked with several broad or numerous narrow dark zones (gray, or in places brick-red in the fossils, probably almost black when they were alive); all had a white subperipheral band.

Length 20, diam. 10.6, aperture 9 mm.; whorls 6½.

Length 20, diam. 11, aperture 10 mm.; whorls 6¼.

Length 19.8, diam. 11.6, aperture 10.3 mm.; whorls 5¾.

The deposit at Kahuku contains many *Tornatellinidæ* and

other fragile snails as well as *Amastra* and various ground shells. They must have lived where they are now found, their preservation being due to the calcareous sand which drifted over the forest-bed. Probably *Achatinella* has nowhere else been found so near the sea—the shore being only a few rods away, and the difference of level not over 10 or 12 feet. It is quite likely however that there has been some subsidence of the island since the forests extended so far down.

Kahana. *A. cæsia cervina* Gulick, of which the type is figured, pl. 43, fig. 12, is a weakly characterized race of *cæsia,* of which very few specimens were found. It is a thin shell very similar to *concidens*, and with much the appearance of *A. buddii*, as Sykes and others have noticed. It is cinnamon colored with softly blending darker streaks and many fine russet lines, which become distinct only on the last half of the last whorl. The suture is narrowly bordered with white, and the embryonic whorls are cinnamon-buff fading to whitish at the apex. A small cream-white area surrounds the columella. The lip is thin, not beveled or thickened within, and like the whole interior is pale pinkish buff, nearly white. Columellar fold central, thin but rather prominent. There is a very short and narrow perforation. Length 19.4, diam. 11, aperture 9.6 mm.; whorls about 6. The smoother surface and central columellar fold differentiate this from *A. c. littoralis*; the shell is thinner and more capacious than *scitula* or *cognata.*

Hakipuu. Mr. Gulick described *A. cognata* and *A. scitula* from this valley. In my opinion the two belong to one race, which would stand as *A. cæsia cognata.* The type-specimen of *cognata*, pl. 44, fig. 8 (no. 60 of the Gulick type collection, Boston Society), is a shell closely resembling *A. dimorpha.* It is moderately solid, very smooth and glossy. The last whorl has pale salmon colored streaks shading into the whitish ground, but on the back of the last whorl the streaks give way to a general sea-shell pink color (*cf.* Ridgway, Color Standards, pl. xiv). The tint is paler towards the suture of the last whorl, and the two whorls preceding are almost white. The embryonic whorls are light buff with a white sutural line, but on subsequent whorls there is a narrow chestnut sutural

line. The lip has a delicate rib close to the edge, which is of the same faintly pinkish white as the rest of the interior. Columellar fold median, rather strong, and pale flesh color; columellar margin refixed and closely adnate. Length 18.3, diam. 10.3, aperture 8.5 mm.; 6¼ whorls.

Mr. Gulick recognized two varieties: "Var. *b*, white; var. *c*, pale green." All of the specimens have the embryo as described above. The dark sutural line of subsequent whorls is never continued upon it as an ocher band, as it frequently is in *A. dimorpha*. In one specimen of the white form there is no dark sutural line, others having it. Gulick's "green" variety is more properly olive-ocher, or tints between that and primrose yellow, always fading to nearly white near the chestnut sutural line. Often the penultimate whorl is colored thus, the color fading out on the last whorl. Specimens of these forms are figured, pl. 44, figs. 9 to 12. All from the Gulick series, No. 92,224 A. N. S. Another shell which probably came from Newcomb, has a distinct yellow band below the white peripheral band, a fainter yellow band above it. The pattern of this shell reminds one of *A. decipiens*.

I agree with Mr. Gulick that *cognata* is quite distinct from *dimorpha*. It is also reported by him from Waikane, but I have not seen these specimens. Both cognata and scitula are imperforate.

The type-specimen of *A. scitula* Gulick, pl. 43, fig. 11 (No. 61 of Gulick's type series, Boston Soc.) has narrow tawny and ochraceous-tawny streaks on a Naples yellow ground, which fades near the suture. There are very weak traces of spiral dusky lines, a stronger one at the periphery, exactly as in the type specimen of *A. cæsia*. The suture is narrowly edged with brown. The embryonic whorls are cinnamon-buff, fading to whitish at the apex, and with an inconspicuous whitish sutural line. The lip is thickened by a distinct narrow, white rib close to the edge. Interior pink tinted. Columellar fold rather weak, central and white. Length 20.2, diam. 11, aperture 9.4 mm., 6⅓ whorls.

Mr. Gulick's statement that the suture and columella are light colored in *scitula* is not borne out by the type-specimen,

which has a distinct if narrow dark sutural margin. His figure also shows this. *A. scitula* seems to be merely a color-form of *A. cæsia cognata.*

The original descriptions of the forms herein referred to *A. cæsia* follow.

"*Achatinella concidens.* Shell sinistral, imperforate, ovate-conic, solid, striated, brown banded with white; apex somewhat acute; spire convexly conic; suture marginate, white, moderately impressed; whorls 6½, convex; columellar fold central, white, moderately developed; aperture truncately oval, white within; peristome thickened within, with external margin unreflected, arcuate; columellar margin dilated, adnate; parietal margin wanting. Length 20, breadth 11, length of body-whorl 14 mm. Average weight 4.75 grains.

"Station, on trees. Habitat, Waimea, Oahu, J. T. G.; My specimens of this species are more or less bleached and faded. Continued search was made for living specimens, but without success" (*Gulick*).

"*Achatinella formosa.* Shell sinistral, imperforate, acuminately ovate, solid, shining, striated, white, with two black bands, one entering the aperture, sometimes with the upper part of the whorl of a pale slate color; apex somewhat acute; spire convexly conic; suture marginate, well impressed; whorls 6½, convex; columellar fold central, white, strong; aperture truncately auriform, white within; peristome thickened within; with external margin unreflected, arcuate, acute; with columellar margin dilated, adnate; parietal margin wanting. Length 20⅓, breadth 10⅔, length of body-whorl 14 mm. Average weight 6 grains.

"Station, on the ki (*Cordyline terminalis*) and other leaves. Habitat, Waimea, Oahu, J. T. G.!

"Var. *b.* with the two bands uniting in one broad black belt.

"Var. *c,* with numerous black spiral lines.

"A rare species, and of great interest on account of its affinities, which connect it with species so different from each other. *A. glauca, delta, phæozona* and *zonata* Nob. are certainly not very similar; but this species seems to connect itself directly with varieties of each of these species" (*Gulick*).

"*Achatinella cognata.* Shell sinistral, imperforate, ovate conic, solid, shining, striated, of pale rosy fawn color, with a brown sutural band; apex subacute; spire convexly conic; suture marginate, brown, lightly impressed; whorls 6, slightly convex; columellar fold central, rose-colored, strong; aperture truncately auriform, within white lightly tinged with

rose; peristome thickened within; with external margin unreflected, arcuate, acute; columellar margin dilated, adnate; parietal margin wanting. Length 19, breadth 10, length of body-whorl 13½ mm. Average weight 5.6 grains.

"Station, on trees. Habitat, Hakipu, Oahu, J. T. G.! Waikane, Frick.

"Var. *b*, white. Var. *c*, pale green. Remarks: allied to *A. dimorpha* Nob." (*Gulick*).

"*Achatinella scitula.* Shell sinistral, imperforate, elongately ovate, solid, shining, striated, streaked with brown and pale fawn; apex subacute; spire convexly elongate; suture marginate, moderately impressed; whorls 6½, convex; columella with a moderately developed white fold near the body-whorl; aperture sinuately ellipsoidal, white within; peristome well thickened within; with external margin unreflected, slightly compressed in the middle, with the anterior edge arcuate; columellar margin dilated, adnate, parietal margin wanting. Length 21, breadth 10⅔, length of body-whorl 13½ mm. Average weight 4.8 grains.

"Station, on trees. Habitat, Hakipu, Oahu, J. T. G.!

"Remarks: There is a green variety which passes into var. *c.* of the last described species. But in that species the suture and columella are dark, while in this they are light-colored.

"*Achatinella cervina.* Shell sinistral, scarcely perforate, ovate conic, rather thin, shining, striated, fawn colored, with obscure brown spiral lines; apex subacute; spire convexly conic; suture obsoletely margined, moderately impressed; whorls 6, convex; columellar fold central, white, sublamelliform, well twisted; aperture sinuately oval, white within, peristome slightly thickened within; with external margin unreflected, arcuate; columellar margin dilated, adnate, parietal margin wanting. Length 20, breadth 11⅖, length of body-whorl 14 mm. Average weight 3.8 grains.

"Habitat, Kahana, Oahu, very rare, J. T. G" (*Gulick*).

Species of the Waianae range.

In the systematic classification these species are about equally related to the series of *A. papyracea* and to that of *A. livida.* All of them are extremely rare shells, each species known from a single small colony only,—and by this we mean a single clump of bananas or the like. *A. lehuiensis* and its variety *gulickiana* have been found but once, and that over fifty years ago, a single individual of each. *A. thaanumi* is known

by two specimens. Only of *A. spaldingi* was a fair series obtained. All of the known colonies are on the northern slope of the range. Who knows how many more wait hidden in dark and difficult ravines, or perhaps a few steps aside from some well-trodden trail!

Probably all of the Waianae forms are descendants of a single species, which migrated from the Koolau range, along with *Partulina dubia* and the ancestor of *Achatinella mustelina*.

28. A. SPALDINGI Pilsbry & Cooke, n. sp. Pl. 42, figs. 1, 2, 3.

The shell is sinistral, imperforate, ovate-conic, ventricose and quite *thin*; white, with slightly interrupted or spotted tawny bands and lines, of which band ii, above the periphery, is the most constant. There is usually a group of bands near the columella, and a space without bands at and below the periphery; suture edged with a band or line of the white ground; apex a trifle dusky. Surface not very glossy, or often dull in old shells, somewhat roughened by growth-wrinkles and irregularly scattered impressions. Whorls convex, joined by an impressed suture. Aperture white and showing the bands weakly within; outer lip not expanded, *thin*, acute. Columellar fold whitish, spiral, small.

Length 16.5, diam. 11.1, aperture 9.2 mm., 5½ whorls.

Length 17.2, diam. 11.1 mm.

Length 17.2, diam. 11 mm.

Oahu, Waianae range: Pukuloa, one-half mile above the Mountain House, back of Leilehua (Spalding). Cotypes in A. N. S. P. and Bishop Mus.; also in coll. Irwin Spalding.

This species has the thin texture of *A. papyracea*, but it is a much more capacious shell, differing in surface and color; the spire is somewhat more attenuate near the apex. Quite old specimens have a thickening within the lip, which is wanting in most adults. It is one of the few *really distinct* species of *Achatinellastrum*. Named for a valued friend of both authors.

29. A. LEHUIENSIS E. A. Smith. Pl. 41, fig. 11.

"Shell sinistral, ovate-conic, somewhat glossy, very finely

striated with growth and transverse lines; white, encircled with a purple-brown streaked zone and two brown zones, one above, the other below the periphery (and sometimes others). Suture submarginate. Whorls 5½, convex. Aperture white; peristome thin; columellar fold strong, rose colored. Length 17, diam. 10 mm." (*Smith*).

Oahu, Waianae range: Lehui [Lihue], on trees (*Gulick*).

Achatinella lehuiensis Sm., P. Z. S. 1873, p. 76, pl. 9, f. 4.

The figured type, No. 74 Coll. Boston Society, is here illustrated. It resembles *A. dimorpha* form *zonata* Gul. rather closely in shape, but the last whorl is slightly more ample; it is, I believe, more closely related to *A. papyracea*. There are two deep chocolate bands separated by a white girdle, one immediately above, the other below the periphery. Adjoining the upper band above there is a zone composed of narrow, brownish vinaceous streaks alternating with narrower whitish ones, and traversed by darker lines near the upper and lower edges. There is a cinnamon line below the white-edged suture, and a small area of the same around the columella; also a dark line near the lower edge of band iii. The embryonic whorls are white, shading to gray at the tip. The aperture has a white lining and a very slight thickening near the edge, which is beveled and acute, in color light brown, with dark markings where the bands terminate. The columellar fold is quite strong and white. I think the statement "*plica columellaris valida, rosea*" was due to dirt and the fact that it has a cinnamon border; but it may *possibly* have faded. The columellar margin is adnate.

The suture has a distinct margin defined by an impressed line on the last whorl, but not colored. The shell is moderately solid, about as in *A. dimorpha*. The unique type measures length 16.25, diam. 10 mm., longest axis of aperture 8.4 mm.

I have described the type-specimen in some detail because the species has not to my knowledge been recovered by recent collectors, and its existence in the Waianae range has been doubted—I believe unnecessarily. It cannot be expected that further specimens, if found, will agree with the type in all details of color-pattern.

The locality "Lehui" (more properly Lihue) was used by Gulick in rather a wide sense, I suppose covering much of the country south of Popouwela, towards Palikea, on the eastern slope of the range. As the form is probably very local, there is hope that it may still be found.

While somewhat resembling *A. dimorpha* form *zonata* Gul., it seems to me to be distinct from that, and from *A. papyracea*. It is certainly quite distinct from *A. casta*.

29*a*. A. LEHUIENSIS GULICKIANA n. subsp. Pl. 42, fig. 4.

The shell is *more conic* than *lehuiensis*, in shape resembling the shorter forms of *A. dimorpha* form *zonata*; solid; white, with a narrow chestnut band just above the periphery, appearing above the suture, and a broad one occupying most of the base; a short distance below the suture an ochraceous band revolves. Embryonic whorls white. Aperture and columellar fold white; the outer lip *not thickened*, stained brown at the terminations of the bands. Length 15.75, diam. 10, length of aperture 8.1 mm.; 5½ whorls.

Oahu, Waianae range: Mokuleia, Gulick coll., No. 1471 coll. Boston Society.

The type is a single specimen in the Gulick collection. If it is really from Mokuleia, it may be a distinct species. Moreover, I cannot connect it with any form of the Main Range. It is not, in my opinion, to be referred to *zonata* Gulick. It cannot be connected with *A. thaanumi*, which has a more elliptical shape. In texture and weight *A. gulickiana* agrees with *lehuiensis*. Except in the structure of the lip it has some resemblance to *A. fuscobasis*.

We would not describe a subspecies from one specimen if it were not important to direct attention to the existence of a member of this group near the western end of the Waianae range.

30. A. THAAMUNI P. & C., n. sp. Pl. 42, figs. 5, 6.

The shell is perforate, sinistral, ovate-conic, thin but moderately strong; white, encircled by two chocolate bands, one above, the other below the periphery; no subsutural band or

columellar dark patch. Embryonic whorls white, becoming blue-gray at the tip. The surface is glossy, marked with fine growth-lines and nearly obsolete spiral striæ. Spire conic with nearly straight outlines and minute apex. Suture very narrowly margined in some, not in other specimens. The aperture has a white lining, showing the bands faintly, but at the thin edge they become vivid, the acute peristome being elsewhere white. It is slightly thickened within. Columellar fold strong and white.

Length 19.1, diam. 11.6, aperture 10.3 mm.; fully 6 whorls.

Length 17.6, diam. 11, aperture 9.25 mm.

Oahu, Waianae range: a gulch of Mt. Kaala running into Haleauau gulch, on banana. D. Thaanum.

This fine species is closely related to *A. lehuiensis*, but differs by being more capacious with larger last whorl and aperture, and somewhat different coloration, lacking subsutural and columellar bands. It may eventually prove to be a subspecies of *lehuiensis* if colonies intermediate in characters are found, but with present knowledge a union of the two is not warranted. *A. thaanumi* is a thicker, smoother shell than *A. spaldingi*, with narrower aperture and somewhat different coloration. It is one of the rarest Oahuan shells, only in the collection of Mr. Thaanum, two specimens, one a dead but fresh shell.

Section Achatinella s. str.

Achatinella Swainson, Quarterly Journal of Sci. and Arts iii, p. 83, 1828.—*Apex* von Martens, Die Heliceen, 1860, p. 248, "type *Achatinella lugubris Chemn.*"—*Helicter* (Fér.) Pease, Proc. Zool. Soc. London 1862, p. 3; 1869, p. 645.—*Helicterella* Gulick, Journal of the Linnean Society of London, Zoology, xi, p. 497, 1873 (name only; no species mentioned).

Shell ovate-conic or piriform, imperforate or minutely perforate, solid. Embryonic whorls nearly flat, the later ones more convex. Aperture quite oblique, the lip very little if at all expanded, well thickened within; columellar fold strongly developed. Type *A. apexfulva.*

Distribution, both ranges of Oahu.

The forms of this group which have been described as species number not less than 53, besides several names for varieties. Doctor Hartman (1888) reduced them to 15; Mr. Baldwin, in his Catalogue of 1893, admitted 32; and Mr. Sykes, 1900, enumerates 17 species with 13 varieties. The lists of synonyms given by these authors differ very widely among themselves, and still more from the synonymy proposed herein. My collaborator Doctor Cooke had worked out an arrangement of all the forms under eight specific heads before I took the group up. Using Cooke's work as a basis, later studies confirm nearly all of his results, but it appears necessary to add *A. swiftii* and *A. leucorraphe* to the list of species, with consequent rearrangement of the synonymy of other forms. With some hesitation, specific rank has also been allowed to the Waianaean *A. concavospira*, making 11 species in all.

It was hoped that characters might be found in the reproductive organs which would aid to indicate specific boundaries, but dissections of *A. lorata, vittata simulans* and *mustelina* show no tangible structural differences.

A consistent arrangement of the species in linear order is impossible, as the group is formed of two parallel series which merge together in the less specialized median species of each.

The minor series consists of *apexfulva, turgida* and *lorata*, species in which the apex is never black or dusky. These forms are confined to the Main range, but do not reach to either end.

In the greater series the tip of the apex is invariably dark in some species (*cestus, vittata, leucorraphe*), and is variable, either dusky or light, in others. The species are distributed over the whole length of both the main and the Waianae ranges.

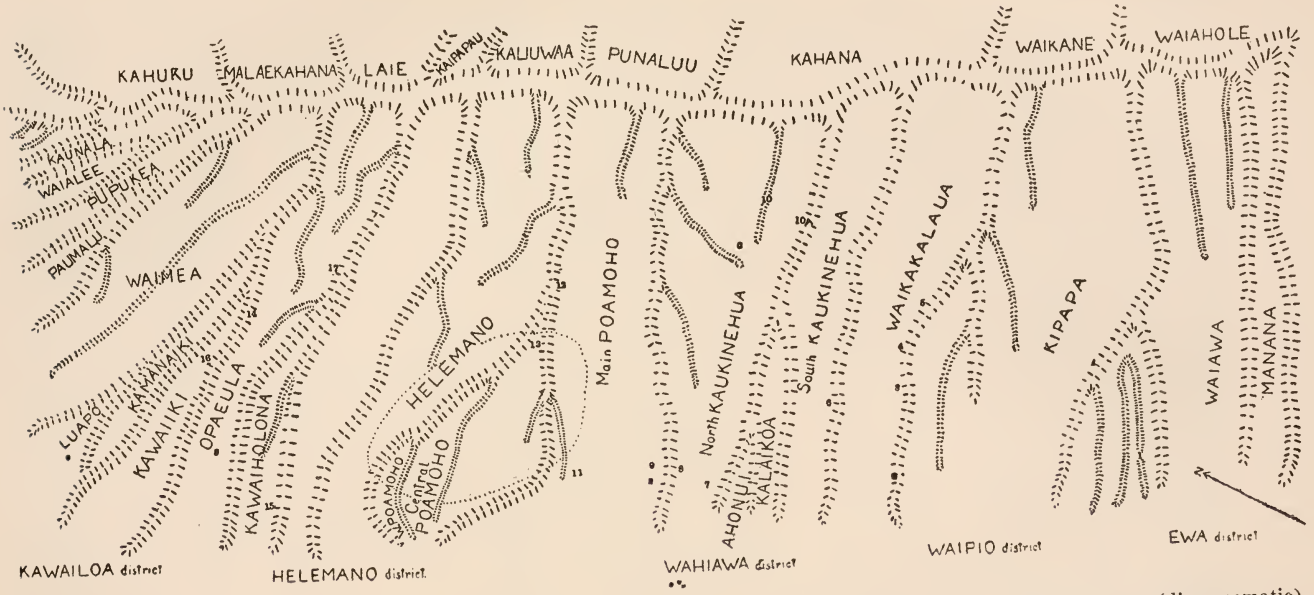
An alternative and probably better grouping may be suggested. (1) Series of lorata, for *A. lorata*. (2) Series of apexfulva, for *A. apexfulva, turgida, swiftii, leucorraphe, vittata, cestus*. (3) Series of decora, for *A. valida, decora, mustelina, concavospira*. See diagram on page 278.

The distribution of the species, so far as positively known

to us, is shown in the accompanying table, in which the valleys of the Main Range are given in order from the west eastward, a few omitted. The ranges given under each species include its varieties and synonyms as understood by the authors.

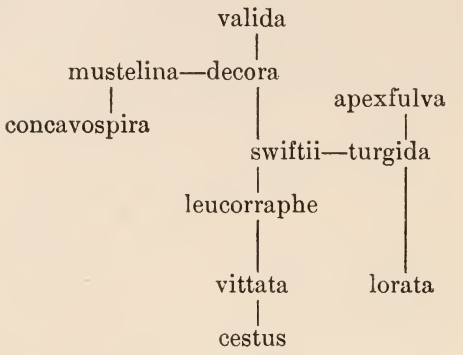
It is remarkable that with the exception of *A. lorata*, no species of this group has been found on the northern side of the Main Range.

Valleys.	Lorata.	Cestus.	Vittata.	Turgida.	Leucorraphe.	Swiftii.	Apexfulva	Decora.	Valida.
Kahuku									*
Waialee									*
Pupukea									*
Waimea									?
Kawaiiki									
Opaeula							*		
Kawaiholona							*	*	
Helemano							*	*	
Poamoho							*		
N. Kaukinehua					*		*	*	
Ahonui					*	*	*		
Kalaikoa					*	*	*	*	
S. Kaukinehua					*	*			
Waikakalaua					*	*			
Kipapa					*	*			
Waiawa	*			*		*			
Manana				*					
Waimano	*			*					
Waiau				*					
Waimalu	*			*					
Kalauao	*			*					
Halawa	*			*					
Monualua	*			*					
Kahauiki	*								
Kalihi	*		*						
Kapalama	*		*						
Nuuanu	*		*						
Pauoa	*								
Makiki	*								
Manoa	*								
Palolo		*							
Waialae		*							
Wailupe		*							
Niu		*							



MAP OF THE INTERIOR VALLEYS OF THE N. W. HALF OF THE MAIN RANGE OF OAHU, FROM FIELD-NOTES OF IRWIN SPALDING (diagrammatic).
The chief colonies of *A. rosea* are enclosed in a dotted line.
Scale 2½ miles to one inch.

The systematic and to some extent the geographic relationships of the species may be approximately represented thus:



In the text the species are arranged in the sequence customary in Hawaiian collections—from the east westward.

31. A. LORATA Férussac. Pl. 51; pl. 52, figs. 1-7.

Shell dextral, ovate-conic, the summit acute, glossy, striate, white with an epidermal color, epidermis uniform or ornamented with bands; whorls 5½, regularly increasing; suture margined; aperture ovate, white; columella arcuate, prominent; umbilical cleft not distinct. Inhabits the Sandwich Islands (*Férussac*).

Oahu: Manoa (and across the range in Maunawili) to Moanalua; varieties further west; the typical forms especially characteristic of the ridges between Nuuanu and Manoa. Usual station on leaves, especially terminal bunches, on guava and many other plants.

Helix lorata FÉR. (Prodrome p. 56, nude name), Voyage auteur du Monde de l'Uranie et la Physicienne, Zoologie, p. 479, pl. 68, figs. 8-12, 1824.—*Achatina lorata* Fér., DESHAYES, Hist. Nat. Moll. ii, p. 193, pl. 155, f. 9-11.—*Achatinella lorata* Fér., NEWCOMB, Ann. Lyc. vi, p. 310 (animal).—PFR., Monographia iv, 524; vi, 168.—THWING, Orig. Descript. p. 13, pl. 1, f. 2.—SEMPER, Reisen im Archip. Phil., Land Moll., pl. 6, f. 23 (genitalia).—*Achatinella hanleyana* PFR., P. Z. S. 1855,

p. 202, species no. 2; Monographia iv, 529. — Sykes, Fauna Hawaiiensis p. 302.—*Achatinella ventrosa* Pfr., P. Z. S. 1855, p. 6, pl. 30, f. 20; Monogr. iv, 535.—*Achatinella nobilis* Pfr., P. Z. S. 1855, p. 202, species no. 1; Monogr. iv, 524.

Achatinella alba Nuttall in Jay's Catalogue, edit. 3, p. 58, 1839 (name only).—*Achatinella pallida* Nuttall, l. c., and in Reeve, Conch. Icon. vi, pl. 1, f. 2, May, 1850.—Pfr. Monogr. iv, 532.

The straightly conic spire, the chalky or porcelain whiteness of the ground, and the tawny and blackish markings make *lorata* quite easily recognized. Its distinctness is rather a matter of feeling, for the shape and color vary so much that a strictly differential diagnosis could hardly be framed. It has the air of a plebeian in a company of aristocrats.

The colors are rather crudely laid on, while most other species of "Apex" are clothed in well blended nuances of brown, ashen or slate, or have clearly drawn lines and bands.

A. lorata is a common shell. In its area one is likely to find it wherever tree-shells occur. The complex of ridges composing the mountain walls between Nuuanu and Manoa valleys are the chief habitat of typical *A. lorata*, though it spreads around the heads of the both valleys, as noted below.

Férussac's figures represent several color-forms, all occurring in Nuuanu. I take his figs. 10, 11 to be the typical pattern. This is represented by pl. 51, figs. 9, 11, from the Nuuanu-Pauoa ridge. His fig. 12 is like the form shown in pl. 51, fig. 14, from the floor of the north side of Nuuanu, the same pattern also extending up the north side. Férussac's other figures (8, 9), were probably from a dead and decorticated specimen of the streaked pattern. The patterns vary from streaked to banded.

1. Yellow (baryta yellow to yellow ocher) with olive, tawny, chestnut or black streaks, pl. 52, figs. 1*a*, 4, 5. There is often a blackish band or patch at the base. Short compact shells with blackish streaks are Pfeiffer's *A. ventrosa*.

2. Same streaked pattern, but cut by spiral white bands, which may be wider than the colored intervals, pl. 52, figs. 1, 3*b*, 6. *A. pallida* belongs to this group, also *A. hanleyana* Pfr.

3. Streaked pattern in large part lost, with the deciduous cuticle, leaving a white shell, colored on the parietal wall. Sometimes with a basal band or patch of chocolate, in the prismatic layer of shell.

4. Cuticle white at all stages of growth; distinguishable from blanched forms of no. 3 by the white parietal wall.

All of these patterns of cuticle are subject to alteration by partial or total loss of the thin colored layer, which is usually more or less deciduous. Any of them may have a dark basal band or patch in the under layer of shell, which is unaffected by loss of cuticle. Patterns 1, 2 and 3 intergrade freely, and usually two, three or all of them may be found in one colony on Tantalus, where it is still rather common, living in bunches of leaves. The same patterns occur in Makiki, pl. 52, figs. 2-3*c*.

Manoa. Mr. Spalding collected a small lot (no. 96 of his collection), in eastern Manoa (I suppose on the division ridge near the main ridge) some years ago,—the most eastern locality known. The shells are plain white or have traces of two yellow bands, columella mostly pink.

Mount Tantalus (pl. 52, figs. 1-1*b*; pl. 51, figs. 4-8), *and Makiki valley* (pl. 52, figs. 2-3*c*). The shell varies a good deal in size and shape, as shown in the figures. The lip and columella are usually a brownish flesh tint (vinaceous pink, Japan rose etc. of Ridgway); rarely white.

A. ventrosa Pfr. and *A. pallida* (Nutt.) Reeve are merely color-forms occurring in mixed colonies together with other patterns, from Tantalus to Nuuanu. They have no racial status. No doubt the types of *pallida* as figured by Reeve were from Tantalus. *A. ventrosa* also has the look of a Tantalus shell, though much the same pattern goes as far west as Moanalua. The original description follows:

"*A. ventrosa* Pfr. [pl. 30, fig. 20, photographic reproduction of Pfeiffer's figure]. Shell imperforate, ovate-conic, rather solid, striate, white, covered downwards with a tawny, black-streaked epidermis; spire conic, obtuse; whorls 5½, inflated, the last a little shorter than the spire, base rounded; aperture nearly diagonal, broadly auriform, white within; columellar fold thick, tooth-like; peristome lipped within, the right mar-

gin unexpanded, rather straightly descending, slightly curved forward, columellar margin short, adnate. Length 17½, diam. 11 mm.; aperture 9½ mm. long, 5½ wide in the middle. Sandwich Islands, Newcomb (*Pfr.*).

The type is in Pfeiffer's collection.

"*A. hanleyana* Pfr. Shell subrimate, dextral, globose-conic, solid, smooth (under a lens very finely spirally striate) glossy; fulvous, radiated with chestnut; spire conic, the apex minute, corneous; suture margined with a crenulated thread; whorls 6, the upper flat, following moderately convex, the last nearly as long as the spire, rounded; aperture oblique, truncate auriform, white within; columellar fold high, strong, tooth-like; peristome lipped within; right margin narrowly reflected, columellar margin dilated, callous, subadnate. Length 18, diam. 11 mm.; aperture with peristome 10 mm. long, 5 wide within. Mus. Cuming, Sandwich Islands, Frick" (*Pfr.*).

Mr. Sykes remarks that this is "related to the form of *A. lorata* described as *A. nobilis*, and may prove to be an extreme variety." Dr. C. Montague Cooke, on examining the type in the British Museum considered it an artificially colored *lorata.*

Pauoa has the same forms as Tantalus, with the addition of a quite elongate form, which comes from the Pauoa-Nuuanu ridge.

Nuuanu. The shell is smaller in the average than on Tantalus, and the lip and *columella* are *paler*, almost or quite white in most shells. The color-patterns are the same as in Tantalus-Makiki shells, but white with one or two dark bands is the usual pattern. Pl. 51, figs. 9, 10, 11 represent shells from the south (east) side of Nuuanu, on lehua trees; pl. 51, figs. 12, and pl. 52, fig. 4 are shells from the north (west) slope, all collected by Dr. Cooke. Figs. 9, 11, 12 are the less common color-patterns. Further Nuuanu shells, from the Gulick collection, are figured, pl. 51, figs. 19-21. Four shells from one tree on the floor of Nuuanu valley above the central crater are shown in pl. 51, figs. 13-16, collected by Dr. Cooke. The next colony westward is that of the summit of the Nuuanu-Kalihi ridge, which differs from forms found

east and west of it sufficiently to be separated as a race, *A. l. nobilis.*

Kalihi. Pl. 52, figs. 5, 5*a*, and pl. 51, figs. 17, 18, coll. by Gulick. The short *ventrosa* and longer *pallida* forms predominate. There are also pure white forms. The lip and columella are white or nearly so. The same streaked or white forms were taken by Mr. Spalding on the central ridge of Kahauiki.

Length 18, diam. 11.8, aperture 10 mm. (*ventrosa* pattern).

Length 20.4, diam. 11.3, aperture 10 mm. (*pallida* pattern).

On the east side of Kalihi Mr. Spalding found the shells all small, length 15 to 17 mm. White, uniform or with a streaked band, or chestnut-streaked on a yellow ground below a white belt.

In Mr. W. D. Wilder's collection there are huge *lorata* from Kalihi—up to 25 mm. long.

Moanalua. A large series in coll. C. M. Cooke shows the short *ventrosa* form exactly as in Kalihi; the same with colored pattern remaining only in bands; and pure white, length 17 to 21 mm. These are from high lateral ridges, pl. 52, figs. 6.

On the floor of the valley near the head on widely scattered *niu*, Dr. Cooke found a small and usually more slender form, length 15 to 19 mm., white, uniform or with a dark peripheral band, sometimes a second one below it (pl. 50, figs. 7, 8). No *ventrosa* occurred here. As in Kalihi shells, the aperture is entirely white.

There is also a series of this small race in the Thurston collection, from the bottom of the north fork of Moanalua, 850 to 1300 ft. I suppose from the same colony where Dr. Cooke collected.

Halawa. A small series coll. by Gulick shows patterns substantially as in the ridges of Moanalua.

Kalauao-Waimalu ridge. Mr. Spalding collected here specimens of unusual color, Vandyke brown with lighter streaks, some of them much smaller than the one figured, pl. 52, fig. 7.

Waimano. A series from the Thaanum collection consists of streaked shells like pl. 52, fig. 5, the cuticle largely lost, and a white form; all solid shells of stout contour (pl. 50, fig. 6, Waimano).

A. lorata form *melanogama* P. & C. Pl. 51, figs. 1-3; pl. 52, figs. 8, 8*a*. The shell is somewhat more slender than in Tantalus *lorata,* with about 6½ whorls; mutations in the hybrid colony as follows. Pl. 52, figs. 8, 8*a,* black, uniform or with indistinct mahogany-red streaks, sutural border and embryonic whorls white or buff; lip black-edged within.

Pl. 51, figs. 1, 2, white, the lower half of the last whorl pale yellow with ocher or ochraceous tawny streaks, sometimes one or two spiral lines; embryo white; peristome vinaceous pink. Sometimes the colored cuticle remains only on the parietal wall.

Pl. 51, fig. 3, white throughout except for the vinaceous pink peristome.

Length 19.6, diam. 10, aperture 9 mm.

Length 18.2, diam. 11, aperture 9.5 mm.

Maunawili, on the north side of the main range opposite Manoa valley—the Kailua flank of Mt. Olympus. Collected by Messrs. D. B. Kuhns and W. D. Wilder. Cotypes 108767 A. N. S. and in Wilder coll.

This is one of the incipient races distinguished by containing certain peculiar color-forms, in a hybrid colony also having normal patterns. Such forms as this are not subspecies in the proper sense, but it is convenient to have names for what seem to be elementary patterns, even though they are not extricated from the parent race.

The black form is a mutation which occurred in a colony of rather lengthened white-ground *lorata.* In the hybrid colony resulting there is complete segregation of the color-forms, in a series of over one hundred individuals seen. Embryos from a typical black mother are figured, pl. 50, figs. 16, 16*a*. They vary from cinnamon to white. I do not know that dark embryos occur in light individuals; all of the latter now before me have white apical whorls.

31*a*. A. LORATA NOBILIS Pfr. Pl. 50, figs. 1 to 5.

On top of the Nuuanu-Kalihi division ridge, at 2000 feet elevation more or less, *A. lorata* is replaced by a race or subspecies which differs by its longer shell of 6½ to 7 whorls

(*lorata* having 5½ to 6). The peristome is usually darker than in *lorata* of Nuuanu and Kalihi, buff-pink to brownish vinaceous; columellar fold the same or nearly white. Patterns various:

Pl. 50, fig. 5, white.

Fig. 2, white, the base finely yellow-streaked or merely tinted, or streaked with tawny or Dresden brown.

Fig. 3, 4, last two whorls yellow, usually with a white band above.

Any of these patterns may be varied by a few chestnut lines or bands on the lower part, as in figs. 2, 3.

Length 22.5, diam. 12.5, aperture 10.5 mm.

Length 23.5, diam. 12, aperture 10.5 mm.

Length 21, diam. 10.5, aperture 10 mm.

The figures are from specimens taken on and around Waolani Peak, where it is rather abundant, from the head of Waolani valley up. This is probably the type locality. The original description follows.

"*A. nobilis* Pfr. Shell subimperforate, dextral, solid, striatulate, glossy, fulvous or grayish-green with darker streaks; spire exactly conic, apex white, acute; suture lightly margined; whorls 6½ to 7, rather flat, the last about two-fifths the total length, obsoletely subangular below the middle; aperture oblique, obauriform, white within; peristome a little expanding, the right margin broadly lipped within, columellar margin subadnate. Length 23, diam. 11 mm.; aperture 10½ mm. long, 5 wide. Island of Oahu, Frick" (*Pfr.*). Type no. 22 of Pfeiffer's collection.

31*b*. A. LORATA PULCHELLA Pfeiffer. Pl. 30, fig. 2; pl. 50, figs. 9 to 14.

"Shell subimperforate, dextral, ovate-conic, nearly smooth, glossy, fulvous with blackish-green bands and sometimes a median band of white; spire conic, attenuate and white towards the acute apex; suture thread-margined; whorls 5½, a little convex, the last about three sevenths the total length, rounded; aperture nearly diagonal, subtetragonal-auriform; columellar fold high, tooth-like, strong; peristome strongly lipped within, the right margin unexpanded, a little straight-

ened, columellar margin reflexed, subadnate. Length 15½, diam. 10 mm.; aperture 8 mm. long, 4 wide inside. Mus. Cuming, Sandwich Islands, Frick'' (*Pfr.*).

Waimano (C. M. Cooke); eastern ravines of Waiawa (Irwin Spalding); Halawa to Waipio (Thwing). Mountains behind Ewa, Perkins (Sykes).

Achatinella pulchella Pfr., P. Z. S. 1855, p. 6, pl. 30, f. 2; Monographia iv, 536.

I have never seen shells agreeing exactly with Pfeiffer's figure, reproduced in pl. 30, fig. 2, but some from Waiawa are perhaps as near as one ought to expect among such variable forms. It is the shell commonly known as *pulchella*. It differs from the *ventrosa* form of *lorata* as found in Moanalua, etc. chiefly by the presence of a darker band below the suture, the more brilliant gloss, and the short spire; but it must be admitted that if it were not already named, we would hardly have thought the race worth a distinctive title.

Shells from the eastern ravines of Waiawa, pl. 50, figs. 9, 13, 14 from Mr. Spalding's no. 255 and 1899, have several patterns:

Pl. 50, fig. 14. Last whorl empire yellow with chestnut streaks, mostly ill-defined, darker next the suture; penultimate whorl white with chestnut-spotted sutural border. Length 17, diam. 10.8, aperture 9 mm.; 6 whorls. Length 15.4, diam. 10.4, aperture 8.6 mm., 6 whorls.

Pl. 50, fig. 13. The same except that the streaks are cut by white bands.

Pl. 50, fig. 11. The same, with two nearly black bands under the cuticle. Waimano (Dr. Cooke). The same form is in the Waiawa lot.

Pl. 50, fig. 9. White, with a chestnut-streaked band below the suture.

Pl. 50, fig. 10. White with greenish (yellowish citrine) bands. Waimano (Dr. Cooke).

Pl. 50, fig. 12. Last whorl streaked with light ochraceous salmon. Waimano (Dr. Cooke).

The specimens in coll. Cooke, reported from the north ridge of Waimano valley, figs. 10-12, are exactly like those from

Waiawa, and I suspect that there is an error in the locality. Mr. Thwing gives *pulchella* an eastern range as far as Halawa. In this direction the separation from *lorata* would become increasingly difficult.

32. A. CESTUS Newcomb. Pl. 29, fig. 8; pl. 52, figs. 12-14*a*; pl. 55, fig. 1.

"Shell solid, ventricose, sinistral or dextral, pointed at the summit; whorls 6, rounded, corded above, last one tumid; aperture subovate; columella short, strongly tuberculate; lip slightly expanded, thickened within. Color of tip black, second and third whorls white, three last white, yellowish or black or mixed, with a white cincture traversing the sutures and cutting the body whorl below the center, with or without a broader band below, sometimes with blotches or tessellations of black and white or longitudinal undulating lines of the same colors. Columella chestnut; lip same color, interrupted with white. Length 14, width 8 twentieths of an inch.

"A fine shell, approaching *A. similans* of Reeve, which it resembles in form, but strikingly differs in markings" (*Newcomb*).

Oahu: Palolo (Newcomb). Western ridge of Palolo to Niu.

Achatinella cestus NEWCOMB, P. Z. S. 1853, p. 132, pl. 22, f. 8; Monographia iv, p. 529, as *var.* of *simulans*.—SYKES, Fauna Hawaiiensis p. 300 (in part).—THWING, Original Descript. etc., p. 13, pl. 1, f. 1.

Achatinella forbesiana PFR., P. Z. S. 1855, p. 5, pl. 30, f. 16; Monographia iv, 529.—THWING, Original Descript. etc., p. 20, not pl. 1, f. 5.—*B*[*ulimella*] *forbsiana* Pfr., HARTMAN, Proc. A. N. S. P., 1888, p. 29.

A. cestus was ill-received by European writers. Pfeiffer considered it a variety of *A. simulans*. Sykes unites with it, as varieties or synomyms, some eight described forms from the Ewa region westward. Hawaiian students—Newcomb, Gulick and the modern collectors—hold *cestus* distinct from all of these. We fully agree with the latter view. The range of *cestus* is widely separated from the similarly marked western forms. There is also a hiatus between the areas of *cestus* and

simulans, wherein no related form occurs. Both by the characters of the shell and by geographic range, *cestus* seems to be somewhat isolated.

Towards the eastern end of the range the shell becomes darker, with various modifications of pattern. It is these most remote eastern forms which look like shells of the western mountains. See under *A. swiftii* of the *polymorpha* pattern.

Palolo.—*A. cestus* was given a wide range of color and pattern in Dr. Newcomb's description, and his figure, reproduced in pl. 29, fig. 8, represents one of the very rare patterns, by no means a fair representative of the species. This pattern was indeed included by him as exceptional,—"sometimes with blotches" etc. The normal or predominant coloration of Dr. Newcomb's collection is shown in pl. 52, figs. 12, 12*a*, representing two specimens received from him.

The ground-color is cinnamon or a tint of that, obliquely marked with streaks (often crenulate or broken into mottling) of chestnut or chocolate, interrupted by a white band or line below the periphery, another often wider, at the base, and frequently a band below the suture. Embryonic whorls are typically white with *a small terminal comma or vortex of deep livid brown* or dark purplish gray; but often the embryo is more or less stained with some tint of ocher or olivaceous. The moderate lip-callus is tinted with flesh-pink. Length 15.5, diam. 11 mm. Length 17, diam. 10.5 mm.

Mr. Gulick collected similar specimens in Palolo. Three unusual color-forms are figured, pl. 52, figs. 14, 14*a*, and pl. 55, fig. 1. A large majority of the shells are sinistral. Mr. Wilder got a few *cestus* on the Palolo-Manoa ridge, which seems to be its extreme range in this direction.

A mutation of *cestus* very distinct in appearance was taken by Newcomb and Gulick in Palolo, pl. 55, figs. 2, 3, 4, coll. by Gulick. The chestnut coloring is reduced to lines and bands at the periphery and on the base. The shell resembles *A. simulans*, but is less robust, the spire more slender, and the columellar margin less developed. Most of those collected by Newcomb and Gulick are sinistral. A small lot, no. 42 coll. Irwin Spalding, consists of dextral shells, which occurred with the

typical color-form of *cestus*. Whether the Gulick lot of this mutation was also in a mixed or hybrid colony is not known. Although this form is not known to occur as a pure race, it may be convenient for reference to designate it as color-form or mutation *simulator*. It is interesting as showing the evolution of a banded form derived from a streaked pattern. Further instances of such transformation will be found under various western species. Form *simulator* has been found only in Palolo, and must now be very rare.

In another form from Palolo, taken by Gulick, the streaks are light brownish olive, and an indistinct, sutural band is somewhat rusty. There are one or two light lines at the periphery, and some dark bands around the columella. These occurred with other specimens of more normal pattern.

Waialae. Gulick found typical *cestus*. Also a form which he identified as *A. forbesiana* Pfr., I think correctly. The streaks vary from russet to dusky drab, cut by white bands and lines which may be few or very numerous (pl. 52, figs. 11, 11*a*, 11*b*). Lip brownish. The original description of *A. forbesiana* will be found below.

In Waialae iki Mr. Spalding found somewhat similar shells, dark *cestus* with a white belt, 3 sinistral specimens. On top of the Waialae iki and Wailupe ridge Mr. Wilder obtained specimens with two white basal bands.

Wailupe. Gulick obtained typical *cestus*, some with the markings very weak, and also a multilineate form resembling the *forbesiana* of Waialae (pl. 52, figs. 13, 13*a*). A fine series from Mr. Thaanum, pl. 52, figs. 9, 9*a*, represents a pure colony of *forbesiana*. The streaks are sepia, dusky drab or dark plumbeous; white spiral lines few or many; interior light blue. A series from the Wailupe-Niu ridge taken by Mr. Spalding are probably from the same place. A few have a narrow white band at the periphery. It varies to quite pale color (pl. 52, fig. 10).

Niu. In a series in coll. C. M. Cooke the shells are similar to the preceding, some browner, approaching the Waialae color.

A. forbesiana is a limital southeastern race of *cestus*, and

might be ranked as a subspecies were it not intimately associated with *cestus* in some Waialae and Wailupe lots. A division of these would scarcely be natural or practicable. The original description follows.

Achatinella forbesiana Pfr. (pl. 30, fig. 16, reproduced from Pfeiffer). Shell dextral or sinistral, subperforate, ovate-conic, solid, closely striatulate, glossy, gray or whitish, painted with close gray or brown bands, frequently confluent. Spire exactly conic, white above, the tip of the apex black, rather acute. Suture margined; whorls 6, a little convex, the last a little shorter than the spire, rounded. Aperture oblique, ob-auriform; columella fold high, strong, nodule-like; peristome bordered with brownish or flesh color, the outer margin narrowly expanded, columellar margin thick, subadnate. Length 19, diam. 10.5, aperture 10 × 5 mm. Sandwich Islands, Frick, in Cuming coll. (*Pfr.*).

33. A. VITTATA Reeve. Pl. 57, figs. 1 to 5*b*.

"Shell dextral, globosely conical, rather ventricose; whorls broadly marginated round the upper part; columella callous, scarcely toothed; lip rather thickened; white, encircled with lines and fillets of pale brown, black at the apex. Sandwich Islands, Mus. Cuming.

"This approaches so closely to the sinistral species *A. decora* [= *simulans*] that it might readily be taken for a dextral variety. The whorls are more rounded and more distinctly margined beneath the sutures. The painting is very similar, but mostly darker next the sutures" (*Reeve*).

Oahu: Eastern ridge of Nuuanu valley; varieties westward to Kalihi.

Achatinella vittata REEVE, Conch. Icon. vi, pl. 2, f. 9, April, 1850.—SYKES, Fauna Hawaiiensis, p. 304; with var. *cinerea* Sykes, p. 305 (1900).—NEWCOMB, Ann. Lyc. N. H. of N. Y. vi, p. 315. — *Helix decora* Férussac, in Freycinet's Voy. Uranie et Physicienne, Zoologie, p. 478, 1824. Not *H. decora* Fér. 1821.—*Achatina decora* Fér., DESHAYES, Histoire Nat., Moll., ii, pt. 2, p. 191, pl. 155, f. 5, 7.—*Achatinella globosa* PFR., P. Z. S. 1855, p. 7, pl. 30, f. 25; Monogr. Hel. Viv. iv, 542.—*Cf.* Thwing, l. c., p. 18.

In the typical form of *vittata* the bands are cinnamon with darker cinnamon brown or Vandyke brown spots, or they may be more rufous, of a hazel hue, shading into chestnut-brown around the columella. The spots on the bands are clearly vestiges of an original streaked pattern, which has been interrupted by spiral white bands and lines. It is a further evolution of the *cestus* pattern. The suture is almost always bordered with a rufous band. The lip has a fleshy tint, and the tip of the apex is invariably dark. The shell may be either dextral or sinistral. This form was collected in Nuuanu (pl. 57, figs. 2 to 2*c*.) by Gulick, exact location not recorded. Reeve's type is a dextral shell. His figure is reproduced, pl. 57, fig. 1. Gulick's shells are both dextral and sinistral. Similar shells, but all sinistral, were taken by Mr. Thwing on the eastern ridge of Nuuanu (pl. 57, figs. 3, 3*a*, 3*b*). This lot is all sinistral and rather small, length about 18 mm.

A fine series was taken by Dr. C. M. Cooke on a spur of the east ridge of Nuuanu opposite Luakaha (pl. 57, figs. 4, 4*a*, 5 to 5*b*). All of the 33 specimens are sinistral. The bands vary from chestnut to claret brown, and are very variable in width, number and grouping, as the figures show. The size and proportions vary widely, two shells measuring:

Length 18.3, diam. 11.3, aperture 9.25 mm.

Length 18.7, diam. 14, aperture 10.7 mm.

The typical form of *vittata* is probably almost extinct at the present time. Pl. 57, figs. 4, 4*a* are *globosa* patterns.

A. vittata differs from *cinerea* and *simulans* by the lighter color of the bands, which are spotted or streaked, the dark sutural border, and the shape, which is less robust than *simulans*. So far as I know it is not found on the western ridge of Nuuanu. If this is the case the herds of *vittata* and *simulans* are separated. The exact location of the colony or colonies of *vittata* where Newcomb and Gulick collected is not known to me, but from Newcomb's statement that it "is met with in Nuuanu valley some three miles from Honolulu" and "the inflated variety designated as *A. globosa* by Dr. Pfeiffer is not uncommon," we may gather that both came from lower Nuuanu, doubtless on the Pauoa side or ridge. The shells

taken by these collectors of sixty years ago are both dextral and sinistral. Those taken by Mr. Thwing and Dr. Cooke ten to twenty years ago, presumably from further up the valley, are exclusively sinistral.

Judging from the short specimens approaching *globosa* among *A. vittata* from Newcomb, and his remark upon the form, I presume that this supposed species was based upon a selected extreme form, probably from the *vittata* colony of southeastern Nuuanu and is not in any proper sense a variety or race. Mr. Sykes considered the type of *globosa* to be *vittata,* and Mr. Thwing has taken the same view. The original description of *A. globosa* follows.

"*A. globosa* Pfr. [pl. 30, fig. 25, photographic copy of original figure]. Shell subimperforate, dextral, conic-globose, rather thin, striatulate, white, encircled with brown lines; spire short, a little convexly conic, subacute; suture lightly impressed, somewhat marginate; whorls 5, moderately convex, the last one obese, about as long as the spire, brown at the base; aperture oblique, subtetragonal-oval, pearly within; columellar fold weak, slightly twisted; peristome acute, brown-edged, somewhat white-lipped within; columellar margin thickened, somewhat adnate. Length 17, diam. 11½ mm.; aperture 10 mm. long, 6 wide. Mus. Cuming. Sandwich Islands, Frick" (*Pfr.*).

33*a*. *A. vittata cinerea* Sykes. Pl. 57, figs. 6, 6*a*, 6*b*, 7.

Banding almost black on the last whorl, ash colored on the whorl above, the upper whorls tinted with pale-brown banding above the suture, replaced by an almost black line at the apex. Nuuanu, Perkins (*Sykes*).

In a series collected by Dr. Cooke (pl. 57, figs. 6 to 7) on a few ridges of the eastern side of Nuuanu just above the dam, the penult. and upper part of last whorl are tea green or glaucous-gray, narrowly streaked with whitish, the last whorl traversed by blackish-chestnut lines which increase and become confluent near the lip; a band bordering the suture and usually a subperipheral band are white; columellar margin cinnamon brown. 28 specimens before me are all sinistral. It occurs as a pure race, varying chiefly in the earlier or later

appearance and spreading of the dark bands. Probably is confined to the district mentioned above.

33*b*. *A. vittata simulans* Reeve. Pl. 57, figs. 8 to 14*c*.

"Shell globosely conical, sinistral, sharp towards the apex; whorls conspicuously margined at the sutures; columella short, flatly callous; white, encircled with a few light-brown lines, with an intense brown band around the columella; lip and columella tinged with light purple. Hab. ——? Mus. Cuming" (*Reeve*).

Oahu: Nuuanu-Kalihi ridges, high up, especially around the heads of Waolani and Kapalama valleys.

Achatinella simulans Reeve, Conch. Icon., vi, pl. 2, f. 15, April, 1850.—Pfr., Monographia iv, p. 528, exclusive of var. *b*. —*Achatinella decora* Fér., Reeve, Conch. Icon., pl. 2, f. 12*a*, *b*. —Thwing, Original Descript., etc., p. 16, pl. 1, f. 3.—*Apex albofasciata* Smith, P. Z. S., 1873, p. 78, pl. 9, f. 21. *Cf.* Thwing, Orig. Descriptions Achatinella, p. 17.

A. v. simulans differs from *vittata* and *cinerea* by its snow-white ground-color with almost black lines and bands, and the usually more solid and robust shell. There is, however, variation in the color of the bands. The type specimen, pl. 57, fig. 8, reproduced from Reeve's plate, was a rather small shell with few bands except close to the lip, where numerous chestnut-brown bands appear, as in pl. 57, fig. 9. Reeve's *A. decora* is merely a larger, more copiously banded form of the same race.

Ordinarily the bands and lines are almost black, various in number and arrangement, rarely confluent, sometimes wanting except at the extreme base. They do not spread or increase in number behind the lip in the vast majority of shells, the type of *simulans* and fig. 9 being quite exceptional. There is no dark streak behind the lip, and the dark apical mark is invariable. A tawny band below the suture is only rarely developed. The spire has slightly concave outlines in most specimens. The basal lip and part of the columella are purplish lilac. Specimens from near and at the summit of the ridge, above the head of Waolani are figured, pl. 57, figs. 10

to 11, east slope of Waolani Peak, coll. by Pilsbry, and figs. 9, 9*a* coll. by Cooke. The same forms extend around the head of Kapalama and onto the Kalihi ridge.

In the same colony from the west ridge of Nuuanu there are exceptional forms with clove-brown, sepia, russet, chestnut or yellow ocher bands, pl. 57, figs. 14*a*, 14*c* Cooke coll., or chocolate, delicately streaked and spirally lineolate with white, with a tawny sutural band as in *A. vittata*, pl. 57, fig. 14*b* Cooke coll. All of the above are sinistral. Some of these unusual color-patterns of *simulans* most resemble *vittata*. One of them also was selected to form the supposed species *A. albofasciata*.

Dextral form.—On a few trees in a little ravine on the western ridge of Kapalama, and in the midst of the sinistral colony, Mr. Spalding found a colony of dextral *simulans*. A light ochraceous buff specimen is shown in pl. 57, fig. 12, but dark-banded shells also were taken. Mr. Gulick found similar ocher-banded dextral shells in "Kalihi"—possibly the same or an adjacent locality.

Apex albofasciata Smith was based, as Mr. Thwing has already intimated, upon a tawny-banded individual of *simulans*, such as are found on the west ridge of upper Nuuanu with the more abundant typical form. The original figure is photographically reproduced on pl. 57, fig. 13. The original description follows.

"*Apex albofasciata* Sm. Shell sinistral (sometimes dextral), perforate, globose-conic, lightly striated with growth-lines; of a bay color, streaked with darker; the last whorl encircled with two or three white zones (the median always wide); apex white; whorls 6, the first four rather flat, the rest convex, suture distinctly margined, white; aperture reddish within; peristome slightly dilated, thickened within, reddish, marked in the middle with the white band of the outside; columellar fold strong, rosy, white at the apex. Length 19, diam. 12½ mm.

Habitat, Sandwich Islands. This species, of which there are several specimens in the British Museum collection, some sinistral and others dextral, I am unable to locate with any yet described" (*Smith*).

Mr. Smith informs me that "the apical half-whorl is tinted with *pale* brown."

34. A. TURGIDA Newcomb. Pl. 29, figs. 10, 10*a*; pl. 56, figs. 1 to 4.

"Shell ventricose, pointed at the apex, sinistral or dextral, smooth, polished, gradually enlarging for four turns and then very rapidly, the last two forming most of the shell; suture slightly impressed, beneath which revolves a linear depression. Aperture subovate; columella short, terminating in a strong conical tubercle projecting into the aperture; outer lip simple, thickened within, slightly tinged with pink or brown; tubercle the same; fauces white; coloring extremely various, ground white, yellow or black, with or without longitudinal zigzag lines, transverse bands or blotches covering the surface. Length fourteen-twentieth, diam. eleven-twentieth inch." (*Newcomb.*)

Oahu: Ewa (Newcomb). Moanalua to Waiawa (or Waipio, Thwing), the typical form westward, various varieties eastward, within these limits.

Achatinella turgida NEWCOMB, P. Z. S., 1853, p. 134, pl. 22, f. 10, 10*a*.—PFR., Monogr., iv, 541.—THWING, Orig. Descript. Achatinella, p. 18, pl. 1, f. 4 ("the metropolis of this shell is Waipio").—*Achatinella cestus* Newc., in part, SYKES, Fauna Hawaiiensis, p. 300, pl. 11, f. 6, 7; not *A. cestus* Newc.

The attempt is here made to define western, median and eastern races of *A. turgida*, as a step towards a systematic record of its local color-differentiation; but I am aware that the material at hand is inadequate. All of the races may run into melanistic phenotypes, by themselves indistinguishable.

The races are these:

A. turgida, Waiawa, pl. 56, figs. 1-2.

A. t. perplexa, Waimano, pl. 56, figs. 5-5*f*.

A. t. simulacrum, Waimano-Manana ridge, pl. 56, figs. 13-14*d*.

A. t. cookei, Waimano-Manana ridge, pl. 57, figs. 15-17.

A. t. ovum, Moanalua to Waimano, pl. 56, figs. 6-10.

Typical A. TURGIDA, *Waiawa*. Doctor Newcomb's figures copied photographically in my pl. 29, figs. 10, 10*a*, and specimens received from him, agree closely with shells taken in the

eastern ravines of Waiawa below the forest fence, no. 1861 coll. Spalding, some of which are illustrated in pl. 56, figs. 1 to 1*c*. It seems likely that the original lot came from this part of Ewa district, and I propose that it be considered the type locality. In one lot taken by Mr. Spalding there are 49 dextral, 38 sinistral shells. The first 2½ whorls are ivory yellow, the next (and last) embryonic whorl nearly or quite white. The following neanic whorls almost always have a nearly black band below the suture. The last whorl varies a good deal in marking.

(1) Ground yellow, mottled with brownish black, the markings sometimes arranged more in bands, sometimes more in streaks (pl. 56, fig. 1*b*).

(2) Ground yellow below, white above the periphery; more or less mottled, and usually with some blackish bands (Newcomb's figure, pl. 29, fig. 10*a;* also pl. 56, fig. 1*c*).

(3) Ground white, variously mottled and streaked or banded with purplish black (Newcomb's figure, pl. 29, fig. 10; also pl. 56, figs. 1, 1*a*, 2).

(4) All post-embryonic whorls black (pl. 56, fig. 4). This pattern is rather rare.

All of these patterns except the last vary individually in amount of marking in any lot, and there are also differences between different lots in average tint. Thus, Mr. Spalding's lot no. 1898, from the forest fence colony, is as a whole darker than his 1861 from the ravines below. One of Gulick's lots, probably from lower down, is lighter than either (pl. 56, figs. 3, 3*a*). These differences are only noticeable in the mass. Rarely two patterns of coloring may be seen on different parts of a single shell, as in the specimen figured by Mr. Sykes, Fauna Hawaiiensis, pl. xi, figs. 6, 7.

The swollen shape of the last whorl in *A. turgida* has been noted by Dr. Newcomb, but the contour varies rather widely. The aperture is bluish white within, lip hardly expanded, well thickened within, flesh color. Whorls 6 to 6⅓. Length 20.3, diam. 13 mm. Length 18.2, diam. 14 mm.

A peculiar pattern, white with gray markings, was noted in the Spalding collection, no. 581, from the central ridge of

Waiawa. As I have not the specimens by me, I cannot say what relation they may bear to the gray form of Waimano.

According to Mr. W. D. Wilder, the yellow form with black lip (var. *ovum*) occurs on the same ridge with mottled *turgida,* but higher up.

34*a*. A. TURGIDA PERPLEXA n. subsp. Pl. 56, figs. 5 to 5*f*.

The shell has a white ground indistinctly streaked with pale neutral gray, and encircled with numerous lines and bands of darker gray or olive brown. First embryonic whorl cartridge-buff with the tip either white or a little darkened, bluish or fleshy, the rest of the embryonic whorls white. First neanic whorl often marked with brown. The lip is vinaceous pink or light brownish vinaceous, fading on the rather strong lip-rib. About 6 per cent are sinistral.

Length 20.7, diam. 13.6 mm., 6⅓ whorls.

Length 18, diam. 12 mm.

Lateral spurs (figs. 5-5*d*), and northern ridge (figs. 5*e, f*) of Waimano valley, C. M. Cooke. Cotypes 1192 Cooke coll. and 108802 A. N. S. P.

The grayish color and pale lip are the chief characters of this race, of which there are about 130 specimens in Dr. Cooke's collection. It varies a good deal. The bluish-gray streaks are often absent, or visible only on the bands, and the latter vary from light to dark. The sutural margin is usually touched faintly or distinctly with tawny. Figs. 5, 5*a* are typical patterns.

In some specimens from the northern ridge of Waimano (pl. 56, figs. 5*e*, 5*f*) the ground is yellowish or cream color, not streaked, and the bands sharply defined, carob brown or almost black. This pattern connects with the gray form through some intermediate shells with gray bands and yellowish ground, and there are also a few shells having gray bands on a white ground, from the northern ridge.

This race seems to be intermediate between *A. turgida* and *A. swiftii.* If found further west, it would inevitably be merged in *swiftii,* on account of the grayish tone of the bands and the perceptible duskiness of the tip in some specimens.

Yet other shells of the lot have the color of the apex and the shape of the shell exactly as in *A. turgida ovum.* As the colony is well within the *turgida* country, and some distance from the area occupied by *swiftii,* it seems more natural to rank the form under *turgida.*

When in Honolulu I noted that a copiously mottled form also occurs in Waimano, no. 3609 and 2050 Spalding coll. In the latter lot there are 42 dextral, 32 sinistral shells. I have not these Waimano valley shells by me, but it may be that they are another pattern of *A. t. perplexa.* Dr. Cooke's no. 1176, which I have figured, pl. 56, fig. 11, is probably a melanistic form of *perplexa.*

34*b*. A. TURGIDA OVUM Pfeiffer. Pl. 56, figs. 6 to 12; pl. 59, fig. 17.

"Shell imperforate, sinistral, globose-conic, solid, rugulose-striate, a little shining, whitish; spire a little concavely conic, apex acute; suture deeply margined; whorls 5½, the upper flat, following convex, the last inflated, slightly shorter than the spire; columellar fold thick, tuberculiform, pale lilac. Aperture diagonal, sinuate-semicircular; peristome unexpanded, bordered with black-brown, with a crenulate lip within. Length 19.5, diam. 13 mm.; aperture 10.5 mm. long, 6 wide. Mus. Cuming. Habitat in the island of Oahu, very rare, Newcomb" (*Pfr.*).

Moanalua to the Waiau-Waimano ridge.

Achatinella ovum PFR., P. Z. S., 1856, p. 334; Monographia, iv, 541.—? THWING, Orig. Descript., etc., p. 19 ("Nuuanu").

The original description of *A. ovum* applies to white examples such as I note below from Halawa, etc. It is a rare white form of a race which is usually some tint of yellow, and generally encircled with *chestnut* bands. There is a black or nearly black streak behind the outer lip, and the *peristome is blackish brown.* A blackish-brown or chestnut band often borders the suture. Mr. E. A. Smith, who examined the type-specimen for me, writes that "the lip is blackish-brown within and without, thickened within, the thickening being slightly crenate, but this crenulation I consider in-

constant. Tip of apex *white*. Striation about the same as in *turgida*. We have dextral as well as sinistral specimens." The type-specimen is shown in pl. 59, fig. 17. This figure has a pinkish tint in my reproduction. It should be cold white.

Moanalua. A series in Dr. Cooke's collection is figured, pl. 56, figs. 7 to 7*d*. The ground is light ocher varying to pinkish-buff or nearly white, variously banded with chestnut, always with a blackish streak behind the lip. Peristome broadly bordered with blackish chestnut. Columellar fold fleshy with white tip. Length 21, diam. 14.3 mm., to length 18.2, diam. 12.2 mm. 24 specimens, all dextral.

On the Moanalua-Halawa division ridge in a series of 13 in Spalding coll., no. 3913, all are sinistral, part white, part with many brown bands. They were found on the mokihana.

Halawa, top of the central ridge. In a series of 15, no. 2225 Spalding coll., all are dextral. The shell is white with black-brown lip, a broad black streak behind it. A few have light brown bands. A white one is figured, pl. 56, fig. 10. The same form has been taken there by Mr. Wilder.

Aiea. In a set of seven in coll. Cooke, three are sinistral. Amber yellow to Naples yellow, sometimes with faint brownish bands or darker lines, similar to fig. 7. Always a blackish streak behind the lip (pl. 56, fig. 6, Aiea, Cooke coll.). Mr. Spalding also collected specimens in Aiea, no. 1820 and 249 of his collection.

Kalauao, small ravine near east crest, no. 2120 Spalding coll. Ground yellow or nearly white, banded with chestnut, black behind the lip. Pl. 56, figs. 8, 8*a*.

Waimalu, and in a gauva forest at head of *Waiau,* Spalding coll.

Also in the Gulick collection there are Waimalu specimens both dextral and sinistral, dark carob brown with some bands of the yellow ground on the last whorl, sometimes almost covered by the blackish color (pl. 56, fig. 12). The light form, pl. 56, figs. 3, 3*a*, was marked Waimalu with a query by Gulick, and may be from further west. Some of the lot are like fig. 1*b*.

Waiau-Waimano ridge. A tawny specimen with narrow in-

conspicuous streaks and faint bands of russet is figured. The sutural band and border behind the lip are blackish. Pl. 56, fig. 9, coll. by Spalding. Mr. J. S. Emerson has a very fine series of the brown-banded form from this ridge.

34*c*. A. TURGIDA SIMULACRUM n. subsp. Pl. 56, figs. 13 to 14*d*.

The shell is sinistral, in shape like *turgida; white* with black or chestnut bands and lines, usually wanting near the suture; embryonic whorls ivory tinted. Peristome *deep livid purple,* the columellar tooth paler or sometimes white. There is a black streak behind the lip.

Length 21, diam. 14.5 mm.; 6⅓ whorls.

Length 20.5, diam. 13.2 mm.

Length 18.6, diam. 13 mm.; 6⅓ whorls.

Waimano-Manana ridge, along the summit trail, above the locality of *A. t. cookei* (Spalding, Pilsbry, Merriam), types 108063 A. N. S. Ridge west of Manana (W. D. Wilder).

This race is intermediate between *ovum* and *cookei,* and specimens can be selected which are transitional towards one or the other. Yet it seems to be a pure race, even though the range of fluctuation in banding is considerable, and it occupies territory a couple of miles long. It begins about one-fourth or one-half mile above the *cookei* colony, and is found thence along the crest of the ridge up to within about a half-mile of the peak on the main range. It has thus a far greater area than *A. t. cookei,* which probably arose from *simulacrum* by a mutation at the lower edge of the *simulacrum* colony. The fully marked, dark shells are mainly in the lower part of its range, nearest to the *cookei* colony. Figs 14 to 14*d* represent shells of the type lot. It differs from most *A. t. ovum* by the white ground, purple lip and black bands; from *A. t. cookei* by having bands above the periphery, and the ground-color is never tawny. Very rarely the whole base is black. The embryos are either pure white above, slightly yellowish below the sharply angular periphery, or they are ochraceous above, buff with an ochraceous band below. No dextral specimens have been found.

On the ridge west of Manana Mr. Wilder found specimens

with a very pale buff ground, variously banded or lineate; also a melanistic form in which the first 2½ whorls are white, next whorl with bands beginning buff, deepening to chestnut, and then to uniform black on the last two whorls. Pl. 56, figs. 13 to 13*b*. This black form resembles the black *turgida* of the mottled colonies westward except in the late embryonic and early neanic stages, which have the banding of *simulacrum*. It is not so rough a shell as *A. byronii nigricans,* the surface being polished and minutely striate as usual in *A. turgida*. Moreover it differs from *nigricans* by having the embryonic whorls more conic, with the suture not at all impressed, while in *nigricans* the embryo is lower, wider, with more convex whorls parted by a noticeably impressed suture.

When studying Mr. Spalding's collection I noted that some specimens in one of his Waimano-Manana lots have a blackish apex. Others of the lot are typical *simulacrum,* with white apex, and in one the whole base is black. The variation in color of the apex in this lot calls for further study.

34*d*. A. TURGIDA COOKEI Baldwin. Pl. 57, figs. 15 to 17.

The shell is dextral or sinistral, with the last whorl bicolored, black or chestnut-black below the periphery, white, light buff or tawny above, usually darker below the suture; peristome livid pink (or brownish vinaceous); embryonic whorls white or ivory.

"Length 21, diam. 15 mm." (Baldwin).

Length 19, diam. 14 mm. (Cotype).

Length 18, diam. 13.2 mm. (Cotype, Proc. A. N. S., pl. 10, f. 15).

Length 20, diam. 13 mm.; 6⅓ whorls.

"Animal: mantle dark slate with a narrow brown band encircling the outer edge. Superior portion of foot light brown, mottled with slate, under surface dingy white" (*Baldwin*).

Waimano-Manana ridge at about 1,800 ft., extending several hundred yards down the Waimano slope.

A. cookei BALDWIN, Proc. A. N. S. Phila., 1895, p. 220, pl. 10, f. 15 (July 2, 1895).

In shape this form varies from short with swollen last whorl

to more straightly conic with longer spire, as shown in the figures. It is often subperforate. Mr. Baldwin's original specimens, from the Waimano slope (at that time reached from the valley) were dextral, with the upper surface buff. One is figured, pl. 57, fig. 15; but among others obtained by Dr. Cooke at the same place there are also some sinistral shells. At the top of the ridge the *cookei* colony reaches to the trail at the summit, but not beyond it, and is very narrow—the matter of a hundred feet or so alongside the trail as I remember. It is longer in the other direction, extending several hundred yards down a small spur. This small colony is the only place *A. t. cookei* has been found. At the upper limit of the colony the specimens are all sinistral (20 in coll. A. N. S., 63 in Spalding coll.). In this sinistral lot from the upper edge of the colony, the peristome is brownish-vinaceous. The black base is produced by coalescence of bands. The bicolored stage may begin as early as the beginning of the fifth whorl, but is sometimes as late as the last half of the last whorl; the bands appearing a little earlier.

A. t. cookei is now recognized by Hawaiian conchologists to be a local race of the many-banded form *simulacrum,* occurring immediately above it on the crest of the Waimano-Manana ridge. Its resemblance to *A. mustelina bicolor* is purely adventitious. The parent stocks of the two were certainly very unlike. "Named in honor of Hon. C. M. Cooke, by whose sons the shell was discovered."

35. A. LEUCORRAPHE (Gulick). Pl. 59, fig. 8.

"Shell dextral, shortly ovate-conic, striated with growth (but scarcely with spiral) lines; gray, ornamented with irregularly interrupted dark cinereous streaks and a few indistinct, white, spiral lines; suture broadly margined with snow white; whorls 6½; apex blackish, first four whorls white, nearly flat, the rest convex; aperture small, somewhat ear-shaped, white; peristome slightly dilated and thickened within; columellar fold large, rosy. Length 19, diam. 12 mm.

"Var. Shell ovate-conic, regularly streaked with dark gray and cinereous; spire straightly conic. [This var. belongs to *A. valida.*]

"Kalaikoa, on the island of Oahu. Waimea ? a variety with spire regularly conical is reported to have been found in Waimea [this = *A. valida* var.]. It is allied, though not very intimately, to *A. apicatus* Nwc. No sinistral form of this species has been found. The specimen figured is from Kalaikoa." (*Gulick.*)

Oahu: Kalaikoa (Gulick). Varieties on the ridges between Kipapa and north Kaukinehua.

Apex leucorraphe GULICK, P. Z. S., 1873, p. 79, pl. 10, f. 2.

The type specimen of *A. leucorraphe*, pl. 59, fig. 8, no. 92 of Gulick's type series, Boston Soc., is a solid, compactly globose-conic shell resembling *A. swiftii* in form. The tip of the embryo is olivaceous black, this shade continues spirally downward above the suture for about 1½ whorls, the upper part of which is white. The last 2½ whorls are olivaceous black or iron gray with streaks and zigzag tracery or mottling of white. At places of growth-arrest and just behind the lip there are brownish streaks. The suture has a white margin broader than the subsutural impression. The aperture and peristome are white, with the faintest suggestion of violaceous. A narrow white line is traced around the periphery, but scarcely noticeable except on the back. Length 19, diam. 12.1 mm.

The unnamed variety noted by Gulick as reported from Waimea is certainly a form of *A. valida leucozona*. Part of the lot is before me.

Recent collectors have not found specimens of the original color-pattern of *leucorraphe*, but a good many shells collected by Messrs. Spalding, Kuhns and Wilder are evidently color-varieties of Gulick's species. The original *leucorraphe* colony in Kalaikoa was doubtless long ago destroyed by recession of the forests. It must have been at the lower limit of the species, which belongs in the main to the high ridges.

35*a*. A. LEUCORRAPHE IRWINI n. subsp. Pl. 59, figs. 9 to 15*a*.

The shell is dextral or sinistral, compactly globose-conic. Embryonic whorls bicolored, white with a dark helicoid spiral which is olive-black or clove brown at the tip (or when the sur-

face is eroded, it becomes dark flesh color), changing to cinnamon buff or some ochraceous tint on the last two embryonic whorls. Later whorls white, encircled with black lines or lines and bands, most numerous on the base; the lines above the periphery often weak and yellowish. Sutural margin usually white, sometimes with a dark line. Peristome pinkish lilac.

Length 19, diam. 13.3 mm.; whorls 6.

Length 16.7, diam. 11.9 mm.; whorls 6¼.

Division ridges between gulches of Kipapa and Waikakalaua, Waikakalaua and Kalaikoa, and Kalaikoa and Kaukinehua, above the 1,500 ft. contour, extending up each ridge to within a mile of the main ridge; abundant on mokihana, ieie, lehua and alani (Irwin Spalding).

By its clean-cut bands on a white ground and dark apical spiral this form resembles *A. vittata simulans* of the Nuuanu-Kalihi ridge, to the point of identity. An expert might distinguish between good lots of each; nobody could rightly separate a mixed lot. Yet the very identity of patterns and their geographic discontinuity makes us suspect it highly unlikely that they belong to the same species, for no *Achatinella* is known to hold a pattern unchanged over so great a distance. It appears that we have to do with two species which have evolved along parallel lines; a smaller western stock in which some colonies retain the ancestral streaked pattern, and a larger eastern, in which the streaked pattern is now rare and rather unlike that of the western species. It is the final stages of each which are so remarkably alike. The nearest colonies of *simulans* and *irwini* are separated by fully one-fourth the length of Oahu, where neither is found, although some similar races of other species occur, such as *A. turgida simulacrum.*

Mr. Spalding has noted that from Waikakalaua four-fifths of the shells are dextral, and in Kaukinehua one-half are dextral. The white ground and dark apex are constant, but there is ample variation in the number and width of the bands. The size varies from about 16 to 19 mm. The banded form from the upper part of the Kaukinehua ridge, figs. 11 to 11*b*, may be taken as typical of *irwini* (from 10A nearly to the

main ridge, on map, p. 277). The Kaukinehua shell, pl. 59, f. 10, is a dextral form of the same color-pattern, but another lot (2095 coll. Spalding) contains similarly banded sinistral shells only.

Mr. Spalding's no. 2042 from the ridge between South Kaukinehua and Waikakalaua (at 6 on map, p. 277), contains a few specimens streaked like those of the southeastern ravines of Waikakalaua (fig. 14*a*); others have a light buff ground, with indistinct pale purplish vinaceous stains in streaks and spirals, deepening to light violet-gray on the back; apical spiral olive brown; lip light pinkish lilac, pl. 59, fig. 9. Others are white with dark spiral lines below, similar to pl. 59, fig. 11*b*. This colony also is a hybrid between the streaked and the banded forms.

Still further southeastward, *A. l. irwini* is found on the Waikakalaua-Kipapa division ridge. In a lot from two miles above Waipio Mountain house (at 5 on map, p. 277), the colony (no. 1986) is chiefly dextral and banded, sometimes with dark subsutural border and reddish bands above the dark ones, sometimes typical (pl. 59, fig. 12, coll. by Spalding); but there are also some streaked shells, like those from lower down. This is therefore a transitional hybrid or undifferentiated colony. There are some very short shells, 15.6 x 12 mm., with 5½ whorls.

Further down the same ridge, in the "southeastern ravines of Waikakalaua, half a mile above Waipio," pl. 59, figs. 14-14*b*, Mr. Spalding collected a series containing some specimens very close to the type of *leucorraphe;* differing mainly in being sinistral (175 sinistral, 4 dextral in his no. 2328 from Station 4 on the map), and in having a tinted lip and a rufous or chestnut line below the suture, instead of a white band. It is a pure race, showing only "fluctuating variation" from dark to light. The dark shells have a summit colored exactly like *leucorraphe;* later whorls with black or olivaceous-black streaks and faint or distinct white spiral lines; lip tinted, fleshy brown. Length 18, diam. 22 mm. The lighter shells have the apical spiral more of a russet-vinaceous hue, and the stripes of the later whorls from cinnamon to walnut

brown, with or without whitish spiral lines; sutural border tawny, lip faintly pink. A small lot of 5 dextral, 4 sinistral shells from Kipapa, in coll. Spalding, are in color like the preceding colony. Pl. 59, fig. 13 is from no. 2328, on the ridge, living on guava, and figs. 14 to 14*b* from no. 1906, lower, on the slope into Waikakalaua. This form of *irwini* resembles the *neglecta* (*coniformis*) pattern of *A. swiftii,* except in the marking of the early whorls, which seems to be a more constant character than the later pattern. It connects with the *irwini* pattern from higher up, through several hybrid colonies, as noted above.

It remains to notice two rather aberrant forms from Mr. Thaanum's collection, possibly having relations with *A. swiftii.*

Pl. 59, figs. 15, 15*a*. A series from Mr. Thaanum labelled "Waipio" (no doubt from somewhere in the lower Kipapa-Waikakalaua ridge) consists of small dextral shells with considerable cinnamon-rufous on the spire and below the last suture, the last whorl or two more or less profusely banded with black, the bands usually somewhat speckled. The apex is marked as in *leucorraphe,* though often rather weakly. The aperture is light Payne's gray within, the lip and columellar fold lavender or fleshy with darker spots. Length 16 to 17 mm.

This is a pure colony of quite distinct appearance.

Pl. 59, figs. 16 to 16*b*. A series of small dextral and sinistral shells from "the *rosea* ridge" (I suppose the middle ridge of Poamoho, or possibly the northern ridge of Waikakalaua), from Mr. Thaanum, contains forms having much the appearance of the *tuberans* pattern of *A. swiftii,* but differing by the well developed, dark, apical spiral of *leucorraphe.* The pattern consists of gray streaks and spiral bands, forming darker squarish spots or short bars at the intersections. Sometimes the bands predominate and are iron gray or blackish, separated by white lines or bands. Lip and columellar fold of a lilac tint, interior bluish white. This form seems near to that from the southeastern ravines of Waikakalaua.

36. A. SWIFTII Newcomb. Pl. 58; pl. 59, figs. 1 to 4*e*, 6, 7.

"Shell ventricose, pointed at the apex, smooth, polished, shining; whorls 6, slightly rounded above, the last strongly inflated, distinctly margined above; lip purplish rose, thick and slightly subreflected; aperture ovate; columella short, terminating in a tubercle of the color of the lip; three first whorls white, the lower with very fine and numerous markings of black and white, arranged longitudinally to the shell, giving it a grayish aspect; fine obsolete white lines traverse the shell transversely, and a white sutural line is traced on the last two whorls. Length fourteen, width ten-twentieths of an inch.

"Var. *a*. With a broad fascia cutting the body whorl.

"Var. *b*. Yellowish ground-color with few markings.

"This species approaches *A. turgida*, but is distinct in appearance, locality and habits" (*Newcomb*).

Oahu: District of Ewa (Newcomb). In its various forms this species probably extends from the western ridge of Waiawa to the ridges of Kaukinehua.

Achatinella swiftii NEWC., P. Z. S., 1853, p. 133, pl. 22, f. 9, 9*a*, 1854; Ann. Lyc. N. H. of New York, vi, p. 325.—PFR., Monogr., iv, 528.—THWING, Orig. Descript. Achatinella, pl. 1, f. 7.—*Apex albospira* SMITH, Proceedings of the Zoological Society of London, 1873, p. 77, pl. 10, f. 8.—*Apex innotabilis* SMITH, P. Z. S., 1873, p. 78, pl. 9, f. 23 (not f. 19).—*Apex neglectus* SMITH, P. Z. S., 1873, p. 78, pl. 9, f. 22.—*Apex versicolor* GULICK, P. Z. S., 1873, p. 80, pl. 9, f. 18.—*Apex flavidus* GULICK, P. Z. S., 1873, p. 80, pl. 10, f. 1, 1*a*.—*Apex coniformis* GULICK, P. Z. S., 1873, p. 80, pl. 9, f. 17 (not f. 23).—*Apex tuberans* GULICK, P. Z. S., 1873, p. 81, pl. 10, f. 3.—*Apex polymorpha* GULICK, P. Z. S., 1873, p. 81, pl. 10, f. 5.

A. swiftii is indifferently dextral or sinistral, though one or the other direction of coil usually predominates in any one colony, sometimes to the exclusion of the other. The embryonic whorls are ivory or ocher-tinted, paler towards the tip which is usually a little dusky, though sometimes flesh-tinted or quite white. The coloring of the adult stage is in

many shades of dull brown and purplish-gray, sometimes with a yellowish cuticle. Streaks predominate, often interrupted by light or dark bands or lines; but the banded patterns are not definite or sharply contrasted as in some related species. I have not seen uniform blackish or white specimens. Newcomb's description of the coloration applies to but a small group in the species; other patterns have given occasion for the definition of several supposed species.

A. swiftii differs from *A. apexfulva* by the shorter, less drawn-out embryonic whorls, which moreover are usually tipped minutely with gray. *A. decora* has special color-patterns, not like those of *swiftii*. *A. valida* has the summit more slender and pointed. *A. turgida* never has a gray tip, and the lip is usually darker. In *A. leucorraphe* the dark tip is much more distinct, and the color-patterns mostly different.. In general, *A. leucorraphe* is a shell of high elevations, while *A. swiftii* inhabited the lower forests. While the various forms of *swiftii* described by Mr. Gulick seem to have been common in the Fifties, they are now nearly or quite extinct, with the forests they adorned. Such as remain are mostly unlike the old lots, being no doubt from places further in the back country. *A. swiftii* is so prolific in color-mutations, so variable in shape, that no definition covering its several forms would serve to exclude the adjacent species. The best that can be said is that with a fair series from any locality, I find no serious difficulty in determining the species.

The supposed species *albospira, innotabilis, neglecta, versicolor, flavida, coniformis, tuberans* and *polymorpha* were based upon selected patterns, most of them known to be out of lots having other patterns which connect all in an inextricable tangle of pattern-combinations. Before me are Gulick's and part of Smith's types, and a series of several hundred shells, mainly collected and named by Gulick. I have gone over them with utmost care; and have been quite unable to find basis for subspecies. Part of the type-specimens are not even common color-forms in the lots they were selected from. So far as I can see, Gulick might as well have divided his material into twenty species instead of eight, since none of them rest upon

any other basis than selected extreme patterns. It will be noted that not less than five of these supposed species were found in two small valleys, Ahonui and Kalaikoa, at the end of the Kaukinehua ridge. The original descriptions are given below in the order of their publication, followed by notes on the types and other specimens.

Typical form of *A. swiftii.*—The original figures of *A. swiftii* are reproduced on pl. 29, figs. 9, 9*a*. Newcomb has stated that "the type figured in the Zoological Proceedings is not the usual pattern of the shell, but is one of the more uncommon varieties." Neither figure agrees in color with his description. The form *described* must therefore be considered the type; not those figured. His fig. 9*a* may be an *A. turgida,* but fig. 9 is apparently *swiftii.*

Two sets, nine specimens, were given by Newcomb to the Academy in 1854. Four of the lot have the white suture mentioned by Newcomb. Two are sinistral. One of these is figured, pl. 58, fig. 1, no. 10313 A. N. S. These shells agree well with Gulick's series from "Wahiawa," except that a white sutural band is very rare in the latter, and the color of the embryo sometimes differs. I consider the Wahiawa region as type locality, though the range of the species in its several patterns lies mainly east of this. Wahiawa shells from the Gulick collection are figured, pl. 58, figs. 2 to 2*c*. The embryonic whorls are not drawn out as in *A. apexfulva.* They are nearly white, but under a lens there is more or less buff or ochraceous tint, either on the second whorl or in form of a band above the suture of the third whorl. The tip may be white, but in several of Newcomb's shells the first half-whorl has a faintly gray or dusky shade. Gulick's Wahiawa shells have the embryonic whorls ivory to pale ocher, the tip white or with the faintest gray tint. The color of the later whorls is in streaks of burnt umber to blackish cut by paler or white spiral lines, which may be numerous or very few. Sometimes the streaks are of some tint of vinaceous drab.

The specimens from Wahiawa which Gulick noted under his description of *A. leucozonus* are in my opinion merely *A. swiftii* with white sutural band. Very few were found, part of them now before me.

Specimens are figured from Kalaikoa valley, from the Gulick collection, pl. 58, fig. 7, and figs. 13, 13*a*, 13*b*. These last were regarded by Mr. Gulick as a form intermediate between *gulickii* and *flavida*, but they seem to me rather *swiftii-flavida*. Pl. 59, figs. 1, 1*a*, 1*b*, selected from Gulick's Ahonui lot, further illustrate the decadence of streaks.

The descriptions of forms considered synonyms of *swiftii* here follow, together with notes on the types and other specimens.

"*Apex albospira* Sm. (pl. 59, fig. 3, type specimen, no. 96 Bost. Soc.) Shell dextral, subperforate, shortly ovate-conic, little shining, striated with growth-lines but hardly spirally; white, a zone above the periphery and the base livid brown; suture lightly margined; whorls 6, the first four a little convex, the rest convex; aperture white; peristome thickened within; columellar fold strong, white, reflexed, nearly covering the small crevice. Length 17, diam. 10.

"Var.: Shell white, ornamented above with a few yellow zones and yellow towards the base, encircled with a few darker zones.

"Reported to be from Ewa, on Oahu" (*Smith*).

The type specimen is an unique, no. 96 of the Gulick type collection, Boston Soc. N. H. The apex and whole embryonic shell are pure white. A band appears just prior to the beginning of the penult. whorl. On the last whorl the band and the whole base are vinaceous drab, lightly streaked with white. Aperture and peristome white. Length 16.2, diam. 10.2 mm. It was probably somewhat dwarfed by misfortune, as there was a break in the fourth whorl, and another, affecting the whole lip, about 4 mm. behind the final peristome. Some of Gulick's *polymorpha* have the same color-pattern, but with a dusky apical tip. However, in some other patterns of *polymorpha* the tip is quite white. There can be no doubt that *albospira* is merely a form of "*polymorpha*" or possibly "*flavida*"—the exact name is not significant, since these Gulickian forms are not real races.

"*Apex innotabilis* Sm. (pl. 59, fig. 7, photographic reproduction of original figure). Shell sinistral, subperforate,

globose-conic, lightly striated with growth-lines; fawn colored, streaked with darker (sometimes ornamented with a few white and brown spiral lines); apex almost white, the nucleus reddish-corneous. Whorls 6, the first four flattened, the rest convex. Suture distinctly margined. Aperture pale reddish within; peristome lightly dilated, thickened within; columellar fold large. Length 18½, diam. 11½ mm.

"Habitat Sandwich Islands. Of a uniform fawn-color, with darker stripes of the same hue, the apex being paler, almost white, and the nuclear whorls reddish horn-colored" (*Smith*).

The type is in the British Museum. I think it is a special pattern of the shell described by Gulick as *A. polymorpha*. The color of the apex is the same, and some *polymorpha* have similar body-color.

"*Apex neglectus* Sm. (pl. 59, fig. 6, photographic reproduction of the type figure). Shell either sinistral or dextral, imperforate, globose-conic, lightly striated with growth lines; dilute brown, streaked with darker or cinereous, umbilical region often chestnut, apex white; spire a little concave; whorls 6, the first four flattened, the rest convex; suture distinctly margined with deep chestnut. Aperture whitish within; peristome brownish, thickened within; columellar fold strong, reddish. Length 17, diam. 11½ mm.

"Habitat Sandwich Islands. In form this species agrees very fairly with some varieties of *lugubris* Chemn.; but it has a shorter spire, and blunter apex than the usual form of that species. The coloration is of a different character" (*Smith*).

Mr. Sykes remarks that "the variety *neglecta* Smith is not really so greenish as represented in the original figure; fig. 23 on the same plate [*innotabilis*, my fig. 7] gives a better idea of the real color." I entirely agree with Mr. Sykes that *coniformis* Gulick is the same thing.

"*Apex versicolor* Gk. (pl. 58, fig. 14, type specimen). Shell sinistral, globose-conic, glossy, striated with growth lines (scarcely with spirals); grayish white, irregularly streaked and zoned with blackish-brown, the base blackish-brown. Suture lightly margined, white (sometimes brown). Spire lightly concave. Whorls 6, the first three pale, a little convex, the rest convex. Aperture white, receding; peristome slightly

dilated, bordered within, tinted with dilute rose-brown; columellar fold strong, pale rose color. Length 19, diam. 13 mm.

"Var.: shell gray-white, scarcely streaked; the last whorl zoned with blackish-brown at the periphery and base.

"Station, on trees; habitat, Ahonui and Kalaikoa, on Oahu. Affinities: it seems to be an intermediate form between *A. decorus* Fér. and *A. tuberans* Gk. This species it always sinistral. The specimen figured is from Ahonui" (*Gulick*).

In the type specimen, no. 101 of Gulick's series, Boston Soc. coll., the first embryonic whorl is gray white, becoming light ochraceous buff on the second whorl, after which white bands appear. The last 2½ whorls have light purplish gray streaks on a white ground. Immediately above the periphery the streaks coalesce into an irregular white-streaked band of blackish Vandyke brown; and a similarly colored area occupies much of the base. The supraperipheral band ascends the spire, forming a narrow dark border above the suture. The lip and columellar fold have a pale flesh tint. Length 18, diam. 13 mm.

There is a large series of *versicolor* from Ahonui in coll. A. N. S., collected by Gulick. An inspection of these shows at once that the type was merely a specimen selected out of a chain of patterns which completely unite *versicolor, tuberans, coniformis* and even *flavida,* all of which Gulick recognized from Ahonui. The *versicolor* pattern also runs inextricably into the *polymorpha* pattern. Several additional *versicolor* of Gulick's Ahonui set are figured, pl. 58, figs. 14*a* to 15. Many specimens are smaller than the type, down to 16 mm. long.

"*Apex flavidus* Gk. (pl. 58, figs. 12, 12*a*, cotypes no. 95 Gulick type coll., Boston Soc.). Shell dextral (sometimes sinistral), shortly ovate-conic, little shining, striated with incremental (but hardly spiral) lines; more or less yellow, encircled in the middle of the whorl with a wide chestnut zone (sometimes two or three zones on the base); suture narrowly margined with brown (sometimes white). Whorls 6, a little convex, the first three always white; spire almost straightly conic, scarcely concave. Aperture whitish, receding; peristome pale rose, slightly dilated; thickened within; columellar fold large, roseate. Length 20, diam 12½ mm.

"Var. *a*. Shell dextral or sinistral, subglobose-conic, yel-

low, encircled with two to six brown or cinereous-brown bands [pl. 58, fig. 12*a*].

"Var. *b*. Shell entirely yellow.

"Station, on trees. Habitat: the metropolis is in Kalaikoa on Oahu; it is also found in Ahonui.

"Affinities: it is most nearly allied to *A. tuberans* Gulick. Remarks: In Kalaikoa all are dextral; in Ahonui one-tenth are sinistral. The specimens figured are from Kalaikoa" (*Gulick*).

The type of *flavidus* is the largest specimen I have seen. It retains the yellow cuticle only on the base. Above the periphery it is white, with a broad Vandyke brown band at the periphery and above the suture, and a brown line below the suture. The embryonic whorls are white with a pale gray tip. This pattern, although selected for the type, is rare. Out of 53 Kalaikoa *flavidus* from Gulick before me, only 5 have it. The bandless form is also rare. Usually there are several bands, of a russet color, or more olivaceous (Dresden brown or Saccardo's olive). Then we have shells with purplish-gray streaks appearing faintly; also, all manner of transitions to the Kalaikoa "*tuberans*." A common pattern is shown in pl. 58, fig. 12*b*, Kalaikoa, Gulick coll., A. N. S. Shells with the yellow cuticle of *flavida* over the oblique streaks of *swiftii* also occur in Kalaikoa, pl. 58, figs. 13-13*b*, Gulick collection. The shells of this lot vary a good deal, like all the Kalaikoa forms of this group. I am rather surprised that Mr. Gulick did not make a species of them, as the more characteristically marked examples, figs. 13*a*, *b*, are as distinct as any of his Kalaikoa-Ahonui species.

"*Apex coniformis* Gk. (pl. 59, figs. 2, 2*a*, Ahonui, and pl. 58, figs. 8, 16, Gulick coll.). Shell sinistral (sometimes dextral), globose-conic, glossy, obliquely striated with growth lines but scarcely spiral lines; brown, streaked with pale brown, indistinctly encircled with several whitish lines; suture margined with deep brown. Spire lightly concave. Whorls 6½, the first 3½ a little convex, whitish, the rest convex. Aperture receding, white; peristome a little dilated and thickened within, the margin tinted with dilute rose (or brown); columellar fold strong. Length 18, diam. 12 mm.

"Var. Shell sinistral, cinereous-brown, streaked with white and encircled with a few white spiral lines; suture brown.

"Station, on trees. Habitat: Kalaikoa and Ahonui, on Oahu; very rare in Wahiawa and Helemano.

"Affinities. It seems to be intermediate between *A. decorus* Fér. and *A. apicatus* Nwc. Remarks: This species is very rarely dextral. The specimen figured is from Ahonui" (*Gulick*).

The *coniformis* pattern always has a brown line or narrow band bordering the suture below. The embryonic whorls are ivory or buff in varying tints, the tip white or sometimes faintly gray. The later whorls are dusky drab, clove brown, or Vandyke brown streaked with lighter brown or creamy. Some are streaked with very pale purplish gray, others almost white. Usually there are pale spiral lines, often scarcely visible, or again quite distinct. All of the specimens figured are from Ahonui, pl. 58, fig. 8 agreeing with Gulick's type.

This form is identical with *A. neglectus* Smith, which is merely one color-tone in the *coniformis* scale. Some specimens connect completely with *swiftii* patterns.

"*Apex tuberans* Gk. (pl. 58, fig. 6, type, no. 93 of Gulick's type series, Bost. Soc.). Shell dextral, globose-conic, glossy, striated with growth (but hardly spiral) lines; cinereous streaked, interrupted with several whitish and blackish-brown zones; suture margined, pallid. Whorls 6, the first three whitish, a little convex, the rest convex; spire concave. Aperture white; peristome slightly dilated, thickened within, tinted with dilute rose-brown; columellar fold strong, whitish. Length 20, diam. 13½ mm.

"Var. *a*. Shell white, variously zoned with brown and buff.

"Var. *b*. Shell yellowish, closely zoned with blackish-brown.

"Station, on trees. Habitat: The metropolis of the species is Kalaikoa, on Oahu. It is also found in Ahonui, and single specimens have been brought from Wahiawa and Helemano.

"Affinities. It is most nearly allied to *A. flavidus* Gk.

"Remarks. This is a dextral species. Sinistral forms are found only in a few specimens passing into other species." (*Gulick*).

The apical whorls are white or ivory yellow, the tip slightly dusky or pale purplish gray. The last whorl, in the type spe-

cimen, is white, streaked with light purplish gray at and above the periphery, cut by white spiral lines. There are several narrow black-brown bands and lines on the base, and two above. Sutural border slightly tinted.

A large lot in the Gulick collection shows wide variation in pattern and color. The ground is often yellowish or yellow at the base. Blackish or chestnut spirals or pale streaks may predominate. Profusely banded specimens come close to the banded forms of *A. leucorraphe*. Others run directly into *flavida* and *swiftii*. Some are figured on pl. 58, figs. 9 to 9*b*, 11, 11*a*, Kalaikoa, Gulick coll.

Forms closely resembling Mr. Gulick's *tuberans* were collected by Mr. Spalding much further southeast.

A lot from the summit of the southeastern ridge of Kipapa, pl. 58, figs. 4, 4*a* from no. 3652 of Mr. Spalding's collection, consists of dextral and sinistral shells. The white apex has a dusky tip, and usually an ochraceous band above the suture of the embryonic whorls, the rest of the spire being white, or with a cinnamon or brown band or line below the suture. The last whorl is grayish olive with a white band or bands, or the grayish tint may appear only in bands at periphery and base. Lip and columellar fold have a pale lilac tint. Some of these shells are very short in contour.

Length 18, diam. 12.7 mm.

Length 17, diam. 11 mm.

Length 15, diam. 11.8 mm.

A lot from one of the minor spurs between the terminal branches of the Kipapa-Waiawa division ridge, pl. 58, figs. 5, 5*a*, 5*b* from no. 2266 Spalding coll., consists largely of shells similar to the preceding, but there are some like those figured, in which black lines or bands are superposed over the other pattern; sutural border cinnamon; lip lavender to lilac. There are also some transitional specimens between these patterns, with the dark bands narrow and rather olivaceous. It is these shells which are nearest to Gulick's *tuberans*. In a lot of 143, all are sinistral. Length 18, diam. 13 mm.

Dr. Cooke took a very pale form of "*tuberans*" on a "low ridge in Wahiawa", pl. 58, figs. 3, 3*a*. They resemble some of Mr. Spalding's Kipapa shells.

"*Apex polymorpha* Gk. (pl. 59, fig. 4 to 4e. Waipio, Gulick coll.). Shell dextral, subperforate, globose-conic, glossy, striated with growth (scarcely with spiral) lines; dilute brown, ornamented with several zones and blue-black streaks, and encircled with a snow-white zone at the periphery. Suture lightly margined, brown. Whorls 6, the first four a little convex, whitish, the rest convex. Spire slightly concave. Aperture white; peristome thickened within, brown-tinted; columellar fold strong, whitish. Length 17, diam. 12 mm.

"Var. *a*. Shell fawn, the suture brown.

"Var. *b*. Shell white, a few zones and the base brown, suture brown.

"Station, on the leaves of the ohia and other trees. Habitat, The typical forms are found in Waipio and Wahiawa on Oahu. Varieties are sometimes found in Kalaikoa and Ahonui.

"Affinities. It is most nearly allied to *A. versicolor* Gk., and *A. tuberans* Gk. Remarks: In Waipio and Wahiawa two-thirds of the specimens are dextral; in Ahonui and Kalaikoa only about one-eighth are dextral. The specimen figured is from Waipio" (*Gulick*).

In the pattern selected by Mr. Gulick as typical, the shell is dextral, brownish drab, varying in shade, and streaked with paler or whitish; there is a white peripheral girdle and some darker spiral lines, the sutural border being tawny or brown. Embryonic whorls ivory, or white shading into yellow towards the suture below, the tip faintly dusky, gray, or sometimes white. This particular pattern is not the commonest, and approaches the *coniformis* pattern. In other shells of Gulick's Waipio lot the color is orange-cinnamon; pinkish buff towards the suture, cinereous below. Pale yellow below, white stained with pale purplish gray above. White with chestnut bands and lines; also other patterns, running into *flavida, tuberans,* etc. See pl. 59, figs. 4-4*e,* Waipio, coll. by Gulick. Pl. 58, figs. 10, 10*a,* Kalaikoa, Gulick. Some of the "*polymorpha*" from Kalaikoa are not distinguishable from *cestus,* though I do not believe them to be directly related to that. I believe it to be a case of the same pattern appearing independently in two derivatives of the same ancestral stock.

A. innotabilis Smith is one of the "*polymorpha*" patterns.

36*a*. A. SWIFTII CHROMATACME n. subsp. Pl. 59, figs. 5, 5*a*, 5*b*.

The shell is dextral, imperforate, solid, with straight-sided or very slightly concave spire; glossy; embryonic shell chestnut brown with pale or whitish spirals, and fading to white at the apex. Later whorls copiously streaked with burnt umber (varying to blackish) on a warm buff ground; the streaks usually blended together more or less, and not reaching up to the suture, and usually interrupted by a white line or band at the periphery. There are also, in some specimens, indistinct pale spiral lines over the streaks. In other specimens of the type lot the ground-color is white, and the markings olive gray; the embryonic whorls colored as in the other pattern. The suture is margined with an impressed line on the last 2½ or 3 whorls. Whorls not very convex, the last a little inflated in some individuals. Aperture pale blue within, the lip and columellar fold lilac, lip dark-edged.

Length 20, diam. 12.5 mm.; 6⅓ whorls.

Length 18.4, diam. 13 mm.

Length 18.4, diam. 12.5 mm.

Waiawa. Cotypes no. 108804 A. N. S. P. and in Bishop Mus., from Mr. Thaanum's collection.

This peculiar form was collected by Mr. Kuhns, who secured a good series. The dark colored embryonic shell with white apex is peculiar and unlike any other known form of the region. The strongly tinted lip and columellar fold as well as the more produced spire are unlike *A. swiftii;* and indeed, *chromatacme* is grouped with *A. swiftii* merely as a temporary expedient, because one feels some diffidence about proposing a "new species" in the *turgida-swiftii* group. It does not seem to be directly related to any form of *A. turgida* I have examined, yet the possibility of such a relationship must be considered.

36*b*. A. (SWIFTII?) DOLIUM Pfeiffer. Pl. 30, fig. 15.

"Shell perforate, ovate-conic, rather thin, lightly striatulate, little shining, pale buff variegated with brownish bands and narrow streaks; spire conic, apex rather acute; suture scarcely marginate; whorls 6, convex, the last a little longer

than the spire, swollen, subcompressed at the base; aperture oblique, obversely ear-shaped, white within; columellar fold high, dentiform, white; peristome thin, sublabiate within, the right margin narrowly expanded, columellar margin dilated, spreading. Length 17, diam. 10 mm.; aperture 10 mm. long, 5 wide." (*Pfr.*)

Sandwich Islands (Newcomb).

Achatinella dolium Pfr., P. Z. S., 1855, p. 5, pl. 30, f. 15; Monographia Hel. Viv., iv, 528.—Sykes, Fauna Hawaiiensis, p. 302.—Thwing, Orig. Descriptions, etc., Occas. Pap. B. P. Bishop Mus., iii, no. 1, p. 102, 1907 ("Kalae, Molokai").

A. dolium is known only by a single specimen, the type, in the British Museum. Mr. E. A. Smith has kindly looked at it for me, and gives the following notes: "*A. dolium* is nearer *vittata* than *lorata* in shape, but not quite the same. It is a much shorter shell than *A. lorata.* The extreme tip of apex (one whorl only) is light olive brown. Spiral striation *hardly traceable.* The lip and interior of aperture are very pale lilac, not white as stated by Pfeiffer."

Comparison should be made with a good series of *A. swiftii. A. dolium* is probably only a color-form of that polymorphic shell. Mr. Sykes considers it a form of *Achatinella* s. str., with this note: "Hab. Molokai (Baldwin). I fancy this habitat must be wrong and that the species really belongs to Oahu; the shell is very close to *A. hanleyana* Pf., and may prove to be only a color variety."

37. A. apexfulva (Dixon). Pl. 50, fig. 15; pl. 60, figs. 1 to 1*c*.

Shell imperforate, dextral, ovate-piriform, solid, very glossy; outlines of the spire concave. 3⅓ *embryonic whorls Naples yellow, following whorls varying from blackish carob brown to chestnut,* sometimes with some whitish streaks and spiral lines; the suture narrowly light-edged; lip flesh or salmon color, columellar fold nearly white. The embryonic whorls are almost flat and are unusually elongated or drawn out, especially the last one. Last whorl inflated. Aperture is bluish white within, the lip moderately thickened.

Length 19, diam. 12.2 to 12.9 mm.; whorls 6.

Oahu: South side of Opaeula gulch near the lower limit of the woodland (J. S. and O. P. Emerson, about 1860). Various varieties from the Kaukinehua ridge to beyond Opaeula.

Helix Apex Fulva Dixon, A voyage round the world; but more particularly to the north-west coast of America, p. 354. —*Turbo Apex Fulva* Dixon, on unnumbered plate, fig. 1, 1789.—*Achatinella apexfulva* Dixon, Sykes, Fauna Hawaiiensis, p. 298.—*Turbo lugubris*, etc., Chemnitz, Neues Systematisches Conchylien Cabinet, xi, p. 278, pl. 209, f. 2059-60, 1795.—*Helix lugubris* Chemn., Ferussac, Tabl. Syst., p. 56 (not *Helix lugubris* Gmel., Syst. Nat., 13, p. 3665).—Ferussac, in Freycinet's Voyage autour du Monde de l'Uranie et la Physicienne, Zoologie, p. 479, 1824.—*Achatinella lugubris* Chemn., Pfeiffer, Monographia, ii, p. 239; iii, 465; iv, 452; vi, 177.—Reeve, Conch. Icon., vi, pl. 2, f. 10*a* (not 10*b*).—Thwing, Orig. Descript., etc., p. 25, pl. 1, f. 6.—*Monodonta seminigra* Lamarck, Anim. sans Vertebres, vii, 1822, p. 37; Edit. Desh., ix, p. 181.—Delessert, Recueil de Coq. décrites par Lamarck, pl. 37, f. 2*a-c*.—*Bulimus seminiger* Mke., Synops. edit. 2, p. 26.—*Achatinella pica* Swainson, The Quarterly Journal of Science, Literature and Art, Series 2, iii, January to June, 1828, p. 84; Zoological Illustrations, iii, 2d Ser., p. 99, pl. 99, f. 1.

A. apexfulva is chiefly characterized by its peculiar nipple-like apical whorls. The embryonic stage has an enameled appearance, the individual whorls being longer and flatter than in related forms (except perhaps some specimens of *A. turgida*). The lip is tinted (except in albinos), but never deep brown or blackish. The tip of the apex is never black or even dusky. Its range lies west of the *turgida* area, and so far as we know at present, several gulches and ridges lie between the areas of the two species. They are certainly near akin.

Pl. 50, fig. 15 is copied from one of Dixon's figures. Pl. 60, figs. 1-1*c* and the above description are from specimens taken by Mr. J. S. Emerson over fifty years ago, in a fine grove of tall, dark-leaved trees on the south side of the deep Opaeula gulch, on the edge of a rocky stream. The area of this grove is estimated by Mr. Emerson as rather less than half an acre.

It was then near the lower limit of woodland, which long ago receded far up the gulch. This colony was composed of entirely typical *apexfulva,* and as the range of single patterns is usually quite restricted, there is good reason to believe that this grove was a remnant of the colony from which the native Hawaiians gathered shells for the *lei* obtained by Captain Dixon.

The colony was a pure one, though showing some "fluctuating variation" by the presence in some individuals of whitish or white spiral lines. Of 49 taken by Mr. Emerson, all are dextral. 33 are blackish carob-brown, fig. 1; 8 chestnut (the shade and gloss of a horse chestnut), fig. 1*a*; 7 faintly marked with white, fig. 1*b*; and 1, immature, banded with white, fig. 1*c*. This last specimen is unique in the colony.

So far as I know, this is the only locality for strictly typical *apexfulva,* in a pure race. In some other colonies that pattern is found in hybrid communities consisting chiefly of other color-forms, such as *A. a. apicata* and *A. a. beata.* Mr. Emerson has two *apexfulva* patterns from high in Helemano, but their associates are unknown to me.

Synopsis of the distribution of the races.—Typical *A. apexfulva* is to be looked upon as an aberrant, melanistic local race of a species widely spread, from Opaeula to Kalaikoa, commonly appearing in a streaked garb, and known as *A. apicata.*

In the central part of its area, *apicata* is chiefly a dark-streaked shell with rufous sutural line. Westward there is a tendency to blend the streaks, and a white sutural band appears. I have called this the *cervixnivea* pattern. On the Poamoho-Helemano ridge this passes into the various forms comprised under the term *beata,* with the shell banded, white or black.

Farther west, on the ridge beyond Opaeula gulch, we have the pink form, *vespertina*; and the black or deep liver-brown form, *apexfulva,* low in the gulch, and now probably extinct.

Eastward there is a peculiar pink-banded race which I have called *A. a. aloha,* on the ridge dividing the upper end of north Kaukinehua. The lower end of the main Kaukinehua

ridge was formerly the habitat of the pattern called *gulickii,* which has a white subperipheral band, and of *lilacea,* with continuous vinaceous streaks. These are now nearly or quite extinct in the localities where Gulick collected.

History of A. apexfulva.—The several synonyms of *A. apexfulva—lugubris, pica* and *seminigra*—were based upon exactly the same form, their types having been taken from leis (necklaces). It appears that shell leis were strung by the natives of the good agricultural region about Waialua Bay, who doubtless got the shells from the lower forests in the back country, in various places in Kawailoa and Helemano districts. They were carried or traded eastward, and so obtained by explorers harboring at Honolulu. It is altogether likely that all of the *A. apexfulva* of these leis were from some one colony in Opaeula Gulch. The Messrs. Emerson's grove may well have been the last remnant of this colony. According to Captain Freycinet, shell leis were going out of style at the time he visited Oahu, the tawdry European ornaments being in fashion. I am glad to say that the charming custom of wearing flower leis continues to this day.

The original descriptions follow.

Helix apexfulva.—"... the natives form necklaces, bracelets and other ornaments. One of these necklaces afforded a singular species of the *Helix* genus of Linnæus, which I was informed is a fresh-water shell. It is outwardly smooth, has seven spires, and is of a black-brown color except the tip which is pale-yellow; the inside is smooth and white, and the mouth is marginated within. It is remarkable for a knob or tooth on the columella, but which does not wind round it, consequently excludes it from the *Voluta* genus of Linnæus, to which at first sight it appears to be related. As I presume it to be a species hitherto undescribed, I have taken the liberty to give it the trivial name of *Apex Fulva,* or the Yellow Tip. A figure of it in two views is given in one of the following plates" (*Dixon*).

A copy of Captain Dixon's figure is given, pl. 50, fig. 15.

In the Neues Systematisches Conchylien-Cabinet, vol. XI, 1795, Joh. H. Chemnitz gives the following description of

Turbo lugubris, prefaced by the statement that Spengler had obtained several shells in London, which were accompanied by a note referring to the account in Dixon's Voyage. "This mirror-smooth shell has six whorls. Its color resembles that of a mourning garment. It is coal-black, and on the uppermost whorls snow-white, and so smooth and shining that I think the shell was polished in the southern lands. The aperture is almost round. The short, white columella is somewhat thickened in the middle, as though there was a tooth there. The interior walls are dirty white. In the Sandwich Islands the natives use these snails for decoration or ornaments to wear on the neck, the ears and the nose. Thus it is that almost all of this species which come to Europe have the shell bored for passage of the band for hanging about the neck or ears."

Chemnitz's figures excellently represent the typical *apexfulva,* and it is very likely that the specimens were part of those brought home by Captain Dixon.

Lamarck's description of the same species follows:

"*Monodonta seminigra.* Shell obliquely conic, imperforate, rather smooth, black below, white above; columellar tooth white; lip simple.

"Inhabits the Pacific Ocean, on the shores of the island of Othaiti. My cabinet. The queen of this island used them for ear rings. The columella is very short. Diameter of the base 5¼ lines; length 7½ lines" (*Lamarck*).

Delessert's figures of Lamarck's type represent entirely typical *apexfulva.* Lamarck does not state the source of his specimens, but Delessert remarks that "il a été rapporté par le capitaine Cook."

Swainson's type of *Achatinella pica* was obtained by Captain (afterwards Lord) Byron in Honolulu. The description follows. " Shell trochiform, black, apex and base of the pillar white. Shell seven-tenths of an inch long, body whorl convex, spire conic; the three upper whorls white or fulvous, without any convexity, and forming a conic point. Suture thickened, and margined by a sulcate groove; a character that runs through all the following species except *A. acuta.* In-

terior of the aperture and base of the pillar white; the latter tinged with rose color; margin of the outer lip within bordered with black."

Swainson's figure is an excellent representation of typical *apexfulva*. He states that Dixon's figures "accurately represent my *A. pica.*" He also thinks *Monodonta seminigra* Lamarck the same species, but leaves the question open, as it had not been figured at that time. In his later publication Swainson places *A. pica* as a synonym of *seminigra*.

Key to subspecies and named color-forms of A. apexfulva.

a. Shell plain or with some whitish spiral lines; suture with a light line or unmarked. Western forms.
  b. Black, with contrasting buff summit. Opaeula. *A. apexfulva.*
  b^1. Pale flesh-colored. Opaeula. *A. a. vespertina.*
  b^2. White, *A. a. alba;* albino forms of *duplocincta* and *beata.*
a^1. Shell conspicuously streaked obliquely. *A. a. apicata.*
  b. Suture with narrow tawny or white margin, *apicata* pattern.
  b^1. The same, with white bands below periphery, *gulickii* pattern.
  b^2. Suture with broad white margin, *cervixnivea* pattern.
a^2. Shell spirally banded, not streaked.
  b. Chestnut or blackish bands and a wide white subsutural band (also with white and black forms). *A. a. beata.*
  b^1. Banded with pink or sometimes black. *A. a. aloha.*
  b^2. Very few brown bands or none, size small, *duplocincta* pattern.

It should be noted that melanistic forms of *apicata* and *beata* are not distinguishable from typical *apexfulva*.

37*a*. *A. apexfulva vespertina* Baldwin. Pl. 60, figs. 2, 3.

The shell is dextral, usually minutely perforate, solid, glossy, with the outlines of the spire more or less concave, apical whorls drawn out, rounded at the tip; pale flesh color

or pale salmon, fading upwards to light buff or ivory, sometimes having narrow, inconspicuous pale bands on the last whorl. Sutural band narrow, usually paler than the ground-color. Lip pale flesh tinted; columellar fold the same or nearly white, strong; columellar margin raised.

Length 20.3, diam. 14 mm.; 6½ whorls.

"Length 21, diam. 14½ mm." (*Baldwin*).

"Animal when extended in motion, longer than the shell. Mantle and tentacles brown, the latter with the head above, of darker shade. Foot light yellow, the superior portion of darker hue." (*Baldwin.*)

Kawailoa (Baldwin); a ridge between Waala [Waialua?] and Kawailoa gulches (Perkins); spur in northwestern Opaeula, on mokihana leaves (Spalding).

Achatinella vespertina Baldwin, Proc. A. N. S. Phila., 1895, p. 219, pl. 10, f. 14.—*A. apicata* var. *vespertina* Baldwin, Sykes, Fauna Hawaiiensis, p. 299.

The rather drawn out and flat embryonic whorls are like typical *apexfulva,* from which this race differs in color. Fig. 2 is the cotype figured by Baldwin; fig. 3 a less inflated specimen from Newcomb. In the locality where Perkins collected it, recorded by Sykes, "Waala" is apparently an error for Waialua. Mr. Spalding has taken it at Station 14 on the map, p. 277. The several localities given all mean this one colony, I believe.

Color-form duplocincta P. & C. Pl. 55, figs. 6, 7, 8.

The shell is dextral, white, encircled with two chestnut bands or groups of lines, one at the periphery, the other below it; lip faintly violaceous. Length 18, diam. 11 mm. Length 17, diam. 11.7 mm.

The cotypes of this form are 1272, 1273 Cooke coll., 108776 A. N. S., and 1213 Gulick coll., Boston Soc. The former lots are labelled "Wahiawa, Emerson, extinct?", three banded specimens, one drawn in fig. 8, and two in which the bands are very faint, a little stronger near the lip. The locality seems open to doubt. The Gulick lot is from "Kawailoa, east side." There is one banded shell, fig. 7, and one pure white

except for a very faint tint on the lip, fig. 6. With them are two small specimens of *vespertina* color, agreeing with the *duplocincta* in size and shape. It seems likely therefore that *duplocincta* is a mutation in a colony of small *vespertina*. If not extinct it may be expected to occur in the vicinity of that race. Whether related to *alba* I cannot say.

37*b*. *A. apexfulva alba* Sykes.

"Shell snow-white, save for the peristome being margined with lilac, similar tinting appearing on the columellar plait and inside the outer lip at its junction with the body-whorl of the shell" (*Sykes*).

Near the head of Kawailoa gulch (Perkins).

Achatinella apicata var. *alba* Sykes, Fauna Hawaiiensis, p. 299, 1900. Not *Achatinella alba* Nuttall, = *lorata*.

This may be a variant of the form I have called *A. a. beata;* but if the locality given is correct, it is probably a parallel modification rather than the same form. Kawailoa is properly speaking the gulch of the Anahulu river, west of Opaeula, while the ridge occupied by *beata* is a considerable distance east of Opaeula. If really from Kawailoa, *A. a. alba* is at the extreme western border of the *apexfulva* area.

37*c*. *A. apexfulva apicata* 'Newc.' Pfeiffer. Pl. 60, figs. 4 to 7*b*.

"Shell imperforate, globose-conic, solid, smooth, blackish or brown, irregularly pallidly radiate and subfasciate; spire conic, apex cinnamon or liver colored, rather acute. Whorls 6, the upper ones flat, the penultimate convex, last whorl globose, scarcely ⅔ the length of the shell. Aperture oblique, subtetragonal-oval. Columellar fold high, tooth-like, lilac colored. Peristome unexpanded, lipped with lilac within, the columellar margin very much dilated, thickened and adnate. Length 18½, diam. 12 mm.; aperture 9 mm. long, 5 wide. Habitat: Sandwich Islands (*Pfr.*).

Kalaikoa to Opaeula.

Achatinella apicata Newc., Pfr., P. Z. S., 1855, p. 210; Monographia, iv, 542.—*A. swiftii* var. Newcomb, Ann. Lyc.

N. H. of N. Y., vi, p. 325.—*Apex gulickii* Smith, P. Z. S., 1873, p. 78, pl. 9, f. 19 (not f. 17).—*Apex lilaceus* Gulick, P. Z. S., 1873. p. 79, pl. 10, f. 4.—*Achatinella aptycha* Pfr., Lyons, Hawaiian Almanac for 1892, pl. 12, f. 32.

Typical *apicata* is figured on pl. 60, figs. 4 to 4*c*. A lot received from Newcomb in 1856 agrees fully with a large series in the Gulick collection from "Wahiawa." The shells are dextral in large majority. The embryonic whorls are flattened and more or less nipple-like, as in *apexfulva*, and usually are between ochraceous orange and ochraceous tawny in color. The later whorls are closely, unevenly streaked in varying shades—Prussian red, dark livid slate purple or dull purplish black, leaving narrower streaks of the ivory or ochraceous buff ground. Sometimes darker or lighter spirals are faintly visible, and rarely an indistinct lighter band at the periphery. The suture usually has a narrow rufous border, rarely white. Occasional shells are warm blackish brown without streaks. Lip fleshy tinted. Except by the usually darker tint of the apex, these dark shells closely resemble typical *A. apexfulva*. Length 20, diam. 13.8 mm. or somewhat smaller.

There is also a large set from Wahiawa collected by Gulick having the typical whitish streaking on a blackish purple ("taupe brown") ground, slightly darker than fig. 4*c*, the embryonic whorls ivory yellow, nearly white.

A large lot collected by Dr. Cooke "on low ridges and valleys, Wahiawa" consists of dextral and sinistral shells in about equal numbers. The blackish and the blue-streaked forms figured from Kaukinehua are present, sutural band hazel to orange or rarely white; apex light ocher or cream color. Other shells are vinaceous gray with whitish streaks and bands. Others of various shades of dull brown, with dark spiral lines and whitish bands (*gulickii* pattern), or not banded (pl. 60, figs. 5 to 5*b*).

The localities of the lots described above are unfortunately rather indefinite, as "Wahiawa" may be anywhere between Poamoho and Waikakalaua.

In north Kaukinehua near the Ahonui ridge, Mr. Spalding collected from the "burnt forest" in a colony (no. 574) where

the apex is brown or ivory-white, coloring various; typically streaked, banded with white (*gulickii* pattern), or nearly white, lip livid pink. Pl. 60, figs. 6, 6*a*.

Further west, near the Kaukinehua-Poamoho ridge, Mr. Spalding collected *apicata* both dextral and sinistral, varying from nearly black through intermediate shades to slate blue or Dutch blue streaked with white, sutural band hazel, orange or chestnut (pl. 60, figs. 7, 7*a*, Station 8, in the western ravines of Kaukinehua); also the *gulickii* pattern, suture pale brown. It occurred also over the ridge on the Poamoho side, east of Nicol's camp, Station 9 of the map, pl. 60, fig. 7*b* from Spalding's no. 317. The *gulickii* pattern with a pale brown suture also occurs here.

It will be noted that these streaked forms are not from the ridges but from the lower slopes. It is likely that the Gulick and Newcomb *apicata* of "Wahiawa" were from still lower forests than those now existing.

In Ahonui and Kalaikoa Gulick found typical *apicata*, like those from Wahiawa, and two forms ranked by him as species (*gulickii* Sm. and *lilacea* Gul.), but which I look upon as merely the locally dominant color-forms of *apicata* with which they intergrade in a small number of specimens. This blending of *lilacea* into *gulickii* and of both into typical Wahiawa *apicata* is fully established by the abundant suites before me collected by Gulick himself. Moreover, occasional specimens of exactly the same patterns may be found among *apicata* in the colonies of "Wahiawa" and Kaukinehua.

The color-pattern called *A. gulickii* Smith is figured on pl. 60, fig. 12, type; figs. 10, 10*a*, 13, topotypes, all from Kalaikoa; fig. 11, from Ahonui, all collected by Mr. Gulick. The streaks vary from dark slate purple to vinaceous drab, and are interrupted on the last whorl by a white zone below the periphery and numerous whitish lines on the base. Typically it has a tawny sutural border, and an ochraceous embryonic shell, fading towards the apex. The lighter colored examples have the sutural band buff or indistinct, and the embryonic whorls pale; the spirals on the last whorl may be reduced to one white line below the periphery, as in fig. 13. The special feature of

gulickii is the presence of a subperipheral light belt, which is seen in various stages of development in a large proportion of the shells (but by no means all) of the original lots. The type-specimen, fig. 12, is one of the shortest in Mr. Gulick's lots. Most shells are like fig. 10*a* in contour. The same color pattern occurs in Wahiawa, figs. 5*b*, 6, 6*a*. The original description follows.

"*Apex gulickii* Sm. Shell sinistral (sometimes dextral), globose-conic, glossy, striated with growth (but scarcely with spiral) lines; dilute brown, streaked with ashy, encircled with a white zone at the periphery; suture margined with brown; spire slightly concave; whorls 6, the first 3 or 4 pallid, a little convex, the rest convex. Aperture white, receding; peristome a little dilated, thickened within, tinted with dilute rose-brown; columellar fold moderately strong, whitish. Length 19, diam. 13 mm.

"*Var.* Shell dextral; first 3 whorls pallid, the following two and the last whorl having the upper half streaked with cinereous-brown, the lower half yellow, zoned with cinereous-brown.

"Station: On trees and bushes. Habitat: this species is most abundant in Kalaikoa and Ahonui, but is sometimes found in valleys to the west as far as Waialei. Affinities: It is allied to *A. apicatus* Nwc. and *A. lilaceus* Gk. Remarks: In Ahonui, two-thirds of the specimens are sinistral. In Kalaikoa only about one-eighth are sinistral. The specimen figured is from Kalaikoa" (*Smith*).

The *variety* of *gulickii* described by Mr. Smith has the epidermis *yellow below the periphery,* markings otherwise as in the *gulickii* pattern. The shells are rather small and thin, mainly dextral. This form, of which I figure specimens on pl. 58, figs. 13-13*b*, is really a form of *A. swiftii* and not closely related to *gulickii*. The statement that this variety occurs "west as far as Waialei" is incorrect, as the Waialee form with yellow base is directly connected with *A. valida cinerosa,* and in my opinion is not the same as the various yellow based forms of *A. swiftii*.

The pattern called *A. lilaceus* (pl. 60, figs. 14, 14*a*, topotypes from Kalaikoa, Gulick coll.) has light brownish vinaceous and russet vinaceous streaks, without white bands, the

narrow sutural margin whitish, the embryonic whorls ivory yellow. The specimens from Ahonui and Kalaikoa are alike in pattern. The original description follows.

"*Apex lilaceus* Gk. Shell dextral, globose-conic, glossy, striated with growth but hardly with spiral lines; lilac-fawn colored, streaked with whitish; suture margined with paler; whorls 6, the first three nearly flat, white, the rest convex; last whorl sometimes obscurely, obtusely angular; aperture whitish; peristome dilute rose-brown, very little dilated, thickened within; columellar fold strong, pale rose. Length 21, diam. 12½ mm.

"Station: On trees. Habitat: The metropolis of the species is Ahonui, on Oahu. It is also abundant in Kalaikoa, but becomes very rare in Wahiawa, Helemano and Kawailoa. Affinities: It is readily distinguished from *A. apicatus* Nwc. by the color of the apex, which is chestnut in that species, but white in this. Remarks: Sinistral specimens are very rare. The specimen figured is from Kalaikoa" (*Gulick*).

This form is fully connected with the *gulickii* pattern.

A. a. apicata occurs on the Poamoho-Helemano ridge in several forms, the shells either dextral or sinistral in the same colonies. A lot in the Gulick collection labeled "Helemano" contains shells with tawny suture, similar to pl. 60, figs. 4*c*, others with narrowly white-margined suture (like pl. 60, fig. 4*b*), and about half the lot has a wide white band below the suture, like pl. 60, fig. 9. In all of these the streaks may vary from walnut brown to slate blue, in various nuances.

On the slope of a spur running into lower Poamoho, Mr. Spalding collected typical *apicata*, chiefly with the suture dark-bordered, but with them the form with broad white sutural band and white embryonic whorls; the streaks slate-blue (pl. 60, fig. 9, from no. 2102).

Further up on the Helemano-Poamoho division ridge the same form occurs. The streaks are more or less blended, color varying from dull violet black to vinaceous drab. The sutural border is wide and snow-white; embryonic whorls cinnamon to nearly white, pl. 60, figs. 8, 8*a*, coll. by Spalding. These shells with a broad white sutural band are an incipient race, in most places not extricated from the dark-sutured

colonies in which the mutation arose. They may conveniently be referred to as the "*cervixnivea* pattern." This pattern is characteristic of the Poamoho-Helemano ridge and its spurs. I suppose that the hybrid *apicata* × *cervixnivea* colonies are chiefly lower than the pure *cervixnivea*. According to a note made from Mr. Spalding's collection his no. 3712, from the central ridge of Kalaikoa is an *apicata* × *cervixnivea* mixture; 3 dextral, 12 sinistral shells.

37*d*. A. APEXFULVA BEATA P. & C., n. subsp. Pl. 60, figs. 17-17*c*; pl. 55, fig. 5.

The shell is dextral, solid, with the embryonic whorls ochraceous-buff (or in white shells, light buff). Subsequent whorls are *never streaked,* but vary in color as follows:

Fig. 5. Pure white, peristome white, embryonic whorls faintly cartridge buff.

Figs. 17*a*, 17*b*. White with several deep chestnut or blackish bands, of which one ascends the spire; last whorl with the band-intervals somewhat violaceous, or the bands confluent; a wide sutural border snow-white; embryonic whorls buff.

Fig. 17*c*. Light buff with chestnut bands, lip pale lilac.

Fig. 17. Last 2½ whorls black with a white sutural line. This is the typical *apexfulva* pattern.

Length 19.6, diam. 12.5 mm.; 6½ whorls.

Crest of the Poamoho-Helemano division ridge, types no. 108809 A. N. S. P., from no. 3430-31 of Mr. Spalding's collection.

This splendid polychromatic race inhabits a limited area on the ridge, at higher elevations than the *cervixnivea* pattern, of which *beata* is merely a specialized, banded form. In fact, the main feature distinguishing it from the *cervixnivea* pattern of *apicata* is that there are *no streaks,* but the color when present is in *bands,* which are a little diffuse at their edges when not lost in a general melanism. I imagine that while the *beata* has been evolved parallel to *A. a. aloha,* the two are not directly connected. Mr. Spalding's no. 3883, from "Helemano, the second ravine above the intersection with Poamoho," is probably part of or near the typical colony of

beata, which includes his no. 3930, 3931, 3853, 3854; the last from far up and upon the ridge, at 12 on the map, p. 277. The first locality is on the lower part of the same ridge.

37*e*. A. APEXFULVA ALOHA P. & C., n. subsp. Pl. 60, figs. 15, 15*a*, 16.

The shell is dextral, rather small and light, often perforate; white, with *unequal spiral bands of pale cinnamon pink* on the penultimate and last whorls, deepening to brownish vinaceous or orange-cinnamon behind the lip, where they usually become confluent. The *embryonic whorls and a broad band below the suture are white.* Peristome moderately thickened within, light purplish vinaceous, the columellar fold paler.

Length 18.5, diam. 12.7 mm.; 6⅓ whorls.

Length 19.2, diam. 11.9 mm.; 6½ whorls.

Crest of the division ridge between the two branches of the Kaukinehua stream, above the Wahiawa head-gates cabin, the colony extending to within ¾ mile of main ridge; on mokihaua, pua, maile and alani. Cotypes in collections A. N. S. P. and Bishop Mus., from no. 3818 Irwin Spalding coll.

By its cleanly-defined pinkish bands, absence of streaks and white embryo, this snail is well distinguished from other forms of *A. apexfulva.* It is very constant in a large series collected by Mr. Spalding, except for a mutation which occurs in the same colony. This is illustrated in pl. 60, fig. 16, and differs from normal *A. a. aloha* only by having the bands chocolate-black.

A. a. aloha is always dextral. It is plentiful in a limited locality on one ridge, which is isolated by perennial streams on both sides, and *mauka* is shut in by the precipitous side of the main Koolau range. This station is marked 10 on the map, p. 277.

Mr. Spalding thinks that connecting forms with *apicata* may perhaps turn up on the upper Helemano-Poamoho ridge, when it comes to be explored. At present, *A. a. aloha* is quite isolated. It is a much less solid shell than *A. a. vespertina,* which is not nearly related.

38. A. DECORA (Férussac). Pl. 61, figs. 1 to 6.

The shell is imperforate, sinistral, solid, ovate-conic, outlines of spire straight or slightly concave. Suture superficial, with the usual impressed line defining a margin, *bordered below by a white band.* Embryonic whorls cream color (varying from almost white to light ochraceous buff), with the tip often a little darker; first neanic whorl often blotched with chocolate, or with a chocolate band, extending as far as the last whorl. Last whorl variously marked. (1) Copiously streaked with chestnut, bay or blackish chocolate on an ochraceous buff ground. (2) The same, with a light subperipheral band. (3) Lightly streaked with chestnut over ochraceous buff, with dark bands below the white sutural band, at the periphery and around the columella, or otherwise placed. (4) Cream or ochraceous buff, not streaked, having a few narrow dark bands, lip nearly white with yellowish edge.

Surface weakly striate, not highly polished. Aperture bluish white within, the lip expanding slightly, well thickened within, and pale flesh color. Columellar fold moderate, nearly white.

Length 21.3, diam. 13, aperture 11 mm.; 6¾ whorls.

Length 19, diam. 13, aperture 10.3 mm.; 6½ whorls.

Length 17.2, diam. 12.8, aperture 9.7 mm.; 6 whorls.

Length 20, diam. 12, aperture 9.5 mm.; 6¾ whorls.

Oahu: Kawailoa and Wahiawa (Gulick). Helemano; Gulch east of Opaeula; gulch west of Helemano; and eastern spurs of Kawaiholona, on kukui trees (Irwin Spalding).

Helix decora FÉR., Tableaux Systématiques des Animaux Mollusques, etc., p. 56, no. 430 (1821), based solely upon *Turbo lugubris sinistrorsus* Chemnitz, Conchylien Cabinet, xi, p. 307, pl. 213, f. 3014, 3015.—*Achatinella decora* var. *b*, PFR., Monogr., iii, p. 465.—*Apex decorus* Fér., GULICK, P. Z. S., 1873, p. 82 (under *A. tumefactus*).—*Achatinella decora* Fér., SYKES, Fauna Hawaiiensis, p. 301, 1900.—Not *A. decora* Reeve, or of most writers and collectors.

Achatinella perversa SWAINSON, Quarterly Journal of Sci., Lit. and Art, iii, 1828, p. 84; Zoological Illustrations, iii, p.

99, pl. 99, f. 2.—Newcomb, Ann. Lyc. Nat. Hist. of N. Y., vi, 1858, p. 309 (animal).—Thwing, Orig. Descript. Achatinella, pl. 1, f. 8.—*Achatinella quernea* Frick in coll., according to J. S. Emerson.—*Apex tumefactus* Gulick, P. Z. S., 1873, p. 82, pl. 9, f. 20.

The shells obtained by Gulick and Newcomb are more variable in shape than those found now. It seems to have been a common species sixty years ago. Pl. 61, figs. 1 to 2*e* represent specimens from the Gulick collection from "Kawailoa," which we take to be the type locality. Whether this form with wide sutural band still exists there is not known. Probably the species ranged farther southeastward in the old days when Gulick obtained his "Wahiawa" lot than it does at present.

Mr. Spalding's several localities are near together, or possibly parts of one or two colonies, in the back Kawailoa-Helemano country.

The shells are rather long, often subperforate, the lip very pale, ground color light buff (or sometimes ochraceous buff) with faint or distinct darker streaks, which are usually straight, sometimes beautifully zigzag. There are dark bands in some lots. *The white sutural band is narrow* or reduced to a line, rarely even wanting. See pl. 61, figs. 4, 4*a*, gulch west of Helemano; figs. 5 to 5*b*, eastern spurs of Kawaiholona; fig. 6, gulch east of Opaeula, where also banded shells occur.

Further east, in "Wahiawa", though just where is uncertain, the species becomes somewhat smaller and distinctly though minutely dark-tipped, the apex being lead color or vinaceous gray. The shell varies from usual *decora* patterns to white with brown bands below the suture, at the periphery and around the columella. Mr. Gulick selected one of the extremely light shells as his type of *A. tumefactus*, but in the large series of his collection this very light form is unusual. It connects with the ordinary dark pattern through many intermediate stages, some of which are figured, all from one lot from "Wahiawa." Pl. 62, figs. 12 to 20; fig. 18 being the typical form of *tumefactus*.

Length 18.6, diam. 12 mm.

Length 16.5, diam. 11.2 mm.

I do not know that *tumefacta* still exists. It was evidently abundant when Gulick collected. There is also a good series in coll. C. M. Cooke, taken by Mr. Emerson at about the same time. Pl. 61, fig. 3 is *decora* from "Wahiawa," Cooke coll.

A. decora has companions in *A. valida* Pfr., from further west, and in *A. mustelina* of the Waianae range. The latter was, in my opinion, derived from an old *decora* stock which migrated southward. Some Waianae shells are hardly distinguishable from main range forms, but in general the *mustelina* variations are different.

Férussac in his first publication based *Helix decora* on the figures in Chemnitz. He seems to have had another shell which he described later (1824) in the Voyage of the *Uranie*. This later *decora* was apparently the banded species subsequently called *decora* by Pfeiffer, Reeve and nearly all later authors and collectors. It is the copiously banded form of *simulans* well known from the western ridge of Nuuanu.

The original *decora* is, as Gulick recognized in 1873, a short, dark form of the shell better known as *A. perversa*. This form was not uncommon in the old days, in colonies mainly composed of longer, more variegated shells. Figures 1*b*, 2*c* of pl. 61 represents "Kawailoa" specimens of *decora* agreeing with Chemnitz's figures. Chemnitz gave the following description: "The shell is smooth as a mirror and brown-blackish colored. Near the suture the whorls are very prettily encircled with a white band. The apex is white. This rare sinistral snail, for which Herr Spengler had to pay two guineas in London, lives in fresh water of the Sandwich Islands in the South Sea. The inner walls are whitish. As the inhabitants of these islands are accustomed to wear this kind of snail as neck and ear adornment, and therefore bore the shells in order to string them, they made no exception of these rare sinistral snails, which are likewise bored."

The type of *A. decora* in the Spengler collection was probably brought to London by the expedition of Captain Dixon.

The species was subsequently described as *A. perversa* and well figured by Swainson, whose shells were from a *lei* brought in England by Captain Byron. The shells on this *lei*

indicate that it was made in Kawailoa district. Swainson's type was a larger, more variegated shell than that figured by Chemnitz, and more fairly representative of the species. The description of *A. perversa* follows. "Shell reversed, subtrochiform, fulvous brown with darker transverse bands and longitudinal lines; apex and suture white" (*Swainson*).

The original description of *A. tumefactus* follows.

"*Apex tumefactus* Gk. Shell perforate, sinistral, globose-conic, glossy, striated with growth and indistinct spiral lines; white, encircled with a few olivaceous-brown zones; suture margined; spire slightly concave; whorls 6, the first blackish, first 3 or 4 a little convex, the rest convex; aperture receding, white; peristome dilated, thickened within; columellar fold strong, white. Length 19, diam. 12 mm.

"Var. *a*. Shell streaked with olive-brown, interrupted by two or three white zones; suture white margined.

"Var. *b*. Shell streaked with fawn, black or brown, interrupted by a wide white zone at the periphery; suture white margined.

"Station. On trees and shrubs. Habitat: Wahiawa; rarely in Helemano. Affinities: It is related to *A. decorus* Fér. (syn. *A. perversus* Swn.), which is found in Helemano and Kawailoa. It is distinguished by its smaller size, its concavely conical spire, and its paler color, which is differently distributed. The three upper whorls of *A. decorus* are of a yellowish tinge; in this species they are white, terminated with a black dot, which is not found in the typical forms of the other species. Remarks: This species is never dextral. The shell figured is from Wahiawa" (*Gulick*).

39. A. VALIDA Pfeiffer. Pl. 30, fig. 24; pl. 52, figs. 15 to 15*e*.

"Shell imperforate, dextral (more rarely sinistral), ovate-conic, solid, smoothish, ashy-brown, somewhat banded with a pale tint and streaked with black. Spire elevated, conic, the apex brown, acute; suture margined, white. Whorls 6, the first three flat, those following a little convex, the last whorl about two-fifths the length, inflated. Aperture oblique, truncate-auriform. Columellar fold above, nodiform, a little twisted; peristome brown-bordered, the right margin nearly unexpanded, somewhat straightened; columellar margin di-

lated, appressed. Length 21½, diam. 13mm.; aperture 10½ mm. long, 5½ wide within.

"Var. *b*. Black, pallidly, interruptedly lineolate or banded. Inhabits the Sandwich Islands, Frick, in Mus. Coming" (*Pfr.*).

Northwestern Oahu: Pupukea, type locality; varieties to Kahuku.

Achatinella valida Pfr., P. Z. S., 1855, p. 6, pl. 30, f. 24; Malak. Bl., 1855, p. 69; Monographia Hel. Viv., iv, 540.

Pfeiffer's type figure is exactly reproduced in pl. 30, fig. 24, and specimens from a large series, collected by Gulick, are figured on pl. 52, figs. 15-15*e*, from Pupukea, which may be accepted as type locality. Out of 62 shells in this set, 36 are dextral. The embryonic whorls form a more narrowly conic summit than in species of the *turgida-swiftii-apexfulva* series, of a *dull red color,* varying in shade between claret brown and ocher red. The last embryonic whorl is overlaid with whitish, also the first whorl, the tip usually being almost white. The spire is straightly conic. The last whorl has a cinnamon ground, more or less profusely streaked and spirally banded or lineate with *brownish black,* or rarely brown. *A sutural band is white,* and rarely there is a white line or band at the periphery. The cinnamon ground fades on the penultimate whorl to whitish on those above. The aperture is white, outer lip faintly brown-tinted.

A. valida is apparently quite distinct from all forms of the interior watershed of the main range. Except in the direction of coil, the large series seen is unusually homogeneous. The broad-banded form, fig. 15*a*, and that without black markings, fig. 15*b*, are very unusual patterns.

In a wider sense, *A. valida* includes the forms described as *leucophæa* and *leucozona* Gulick; yet as the several races occur in pure colonies so far as we know, they may stand as subspecies. On the extreme limits of their variation are a few more or less intermediate specimens. Further exploitation of the ridges would probably diminish the distinctions. 372 shells of all the races are before me.

39*a*. A. VALIDA LEUCOPHÆA (Gulick). Pl. 55, figs, 19 to 22.

"Shell sinistral, subperforate, ovate-conic, little shining, indistinctly, very finely striated with growth-lines and transversely; dilute fawn, streaked and zoned with pale brown; suture distinctly margined with white. Whorls 7, subconvex. Aperture white; peristome a little dilated, strongly thickened within, tinted with pale brown. Columellar fold strong, whitish, slightly reflected, nearly covering the small crevice. Length 22, diam. 12 mm.

"It is allied to *A. perversus* Swn. and *A. validus* Pfr., but it is of a paler color and more elongate form. It is always sinistral" (*Gulick*).

Waialee (Gulick).

Apex leucophæus GULICK, P. Z. S., 1873, p. 82, pl. 9, f. 16.

In a series of 105 specimens, all are sinistral and most are imperforate. The embryonic whorls are ochraceous or light brown, darkest near the suture below, fading upwards, the tip dilute brown. The later whorls have a light pinkish cinnamon to cartridge buff ground, weakly marked with cinnamon streaks and spiral lines or narrow bands. The very narrow sutural border is pale. The lip has a faint fleshy brown or cream tint. The spire is straightly conic and typically rather long. A small proportion of specimens are indistinguishable in shape and color from the lighter forms of Pupukea *valida*.

Length 22, diam. 12.8 mm.; 6¾ whorls.

Length 19, diam. 12.3 mm.
Length 19, diam. 9.1 mm. } extremes of shape.

39*b*. A. VALIDA CINEROSA Pfeiffer. Pl. 30, fig. 5; pl. 55, figs. 9 to 18.

Shell dextral, imperforate, ovate-conic, solid, nearly smooth, glossy; brown-gray, radiated with brown and white lines. Spire conic, apex rather acute, white; suture somewhat crenulate, white-bordered; whorls 6, a trifle convex, the last a little shorter than the spire, rotund at base. Aperture a little oblique, truncate-auriform; columellar fold twisted, strong; peristome thickly white-lipped, the right margin somewhat

straightened, narrowly expanded; columellar margin thick, adnate. Length 21, diam. 11mm.; aperture 10 mm. long, 4½ wide. Inhabits the Sandwich Islands, Frick (*Pfr.*).

"Var. *b*. Fulvous, radiated with brown, suture of the same color" (*Pfr.*).

Oahu: Waialee (Gulick).

Achatinella cinerosa Pfr., Proc. Zool. Soc., 1855, p. 2, pl. 30, f. 5; Malak. Bl., 1855, p. 5; Monographia Hel. Viv., iv, 519.—[*A. decora*] var. *cinerosa* Pfr., Sykes, Fauna Hawaiiensis, p. 302.—*Apex leucozonus* Gulick, P. Z. S., 1873, p. 83, pl. 10, f. 6.

This subspecies is like *valida* in the straightly conic shape, white subsutural band and streaked coloring. It differs from *valida* chiefly by the color of the embryonic shell, which varies from ivory to light ochraceous buff with a white band below the suture; the tip white or a trifle grayish. The last two or three whorls are cinnamon with snuff-brown to sepia streaks (rarely walnut brown), in many specimens interrupted by a white peripheral band; suture bordered with a white band. Rarely there are several or numerous bands, figs. 9, 14, illustrating these unusual patterns. In a few shells the streaks coalesce, producing an even chocolate shade, with the usual light peripheral and sutural bands. In a few specimens the cuticle is yellow below the periphery (fig. 10). Some narrow shells of this kind were erroneously identified by Gulick as *A. napus* Pfr., but that is really a Waianae shell. In several very old shells there is a strong cord across the parietal wall. The color and shape variations are well connected by intermediate shells, in the lot of 178 before me, even the yellow-base form, which seems to be the only significant color-mutation in the lot, connects by transitional shells with the others. Gulick states that it is always dextral, but I found three sinistral shells by carefully looking over the lot in A. N. S. collected by him.

The ordinary size is length 19, diam. 11.7 mm., but it may be smaller and narrower, length 17.2, diam. 10.4 mm.

The specimens from Wahiawa noted in Mr. Gulick's remarks under *A. leucozonus*, belong, in our opinion, to *A. swiftii*.

It happened that the same streaked pattern of what seems to have been a common Waialee shell served as the types of *cinerosa* and *leucozonus,* so that the two names are exactly synonymous. The original description of *leucozonus* follows. The original figure is like my pl. 55, fig. 12.

"*Apex leucozonus* Gulick. Shell subperforate, dextral, globose-conic, glossy, striated with incremental (but scarcely spiral) lines; gray-brown, streaked with deep gray-brown, at the periphery interrupted by a white zone; suture distinctly margined with white. Spire straightly conic. Whorls 6, the first three a little convex, the rest convex. Aperture white; peristome a little dilated, tinted with pale rose-brown, thickened within; columellar fold strong, white. Length 19, diam. 12 mm.

"The metropolis of this species is Waialei. A few specimens have also been found in Wahiawa, Island of Oahu. It is related to and passes into *A. napus* Pfr., which is also found in Waialei; but the usual forms are distinguished by having a shorter spire and a white suture, and in being free from the yellowish hue of that species. This species is always dextral. The specimen figured is from Waialei" (*Gulick*).

A rather peculiar form of *cinerosa* (pl. 55, figs. 17, 18) was noticed by Mr. Gulick under his description of *A. leucorraphe*: "a variety with spire regularly conical is reported to have been found in Waimea." This shell is certainly a form of *cinerosa* (*leucozona*), and not of *leucorraphe.* The embryo is shaped like that of *valida,* ivory or buff with a fleshy tip; last whorl light pinkish cinnamon to pallid purplish gray, narrowly and closely streaked with brownish or slaty shades, usually with a few inconspicuous dark lines around the base. The suture has a wide white border, but there is no peripheral band. Lip white. All of a series of 21 are dextral. The locality *Waimea* is marked with a query in Mr. Gulick's collection, but no doubt the form came from somewhere in the northwest, and may have been from Waimea.

39*c*. A. VALIDA KAHUKUENSIS P. & C., n. subsp. Pl. 52, figs. 17, 17*a*.

The shell is dextral, white above, yellow below the periphery,

usually encircled with a black-brown line at the junction of the two ground-tints, and often there are several additional lines widely spaced on the base or sometimes above. A faint sutural line may usually be discerned. Embryonic whorls when unworn are cartridge buff, slightly darker near the sutures, but not at the tip. The outlines of the spire are perceptibly concave, the last whorl swollen. Lip moderately thickened, white; columella very faintly rose-purple.

Length 20, diam. 13 mm.; 6½ whorls.

Length 18.7, diam. 12.2 mm.; 6½ whorls.

Oahu: Kahuku, at an elevation of 1,500 to 1,750 ft. (L. A. Thurston). Cotypes in coll. A. N. S. and Bishop Mus., from Mr. Thurston's collection.

This race is one of the most attractive of the "*Apex*" group. While very distinct in appearance, its kinship with the *valida* series is shown by the rare yellow-based form of *cinerosa,* which however does not have the *turgida*-like shape of the Kahuku form.

Mr. Spalding informs me that there are black and white mutations of this Kahuku race.

Species from the Waianae Range.

Affinities and origin.—The species *A. mustelina* is now considered by Hawaiian conchologists to include all the Waianaean forms of the typical section of *Achatinella* (*Apex*), with the possible exception of *A. concavospira.* In this wide sense the species inhabits the whole range, where conditions are suitable. It is often very abundant. It is related to *A. decora* Fér. and *A. valida* Pfr. of the Main Range. Some specimens of *decora* are hardly separable from *mustelina,* but in the main, the variations of the two differ rather widely. *A. decora, valida* and *mustelina* appear to be slightly differentiated forms of a common ancestral species which lived in the western valleys of the Main range of Oahu. The migration to the Waianae range may have begun in a late stage of the Pliocene, but more likely in the Pleistocene. Up to historic time forests extended from range to range, and *Amastra, Pterodiscus* and other forest snails of the two ranges mingled. The more an-

cient Waianae fauna probably had no arboreal Achatinellæ; at least we have no evidence of any.

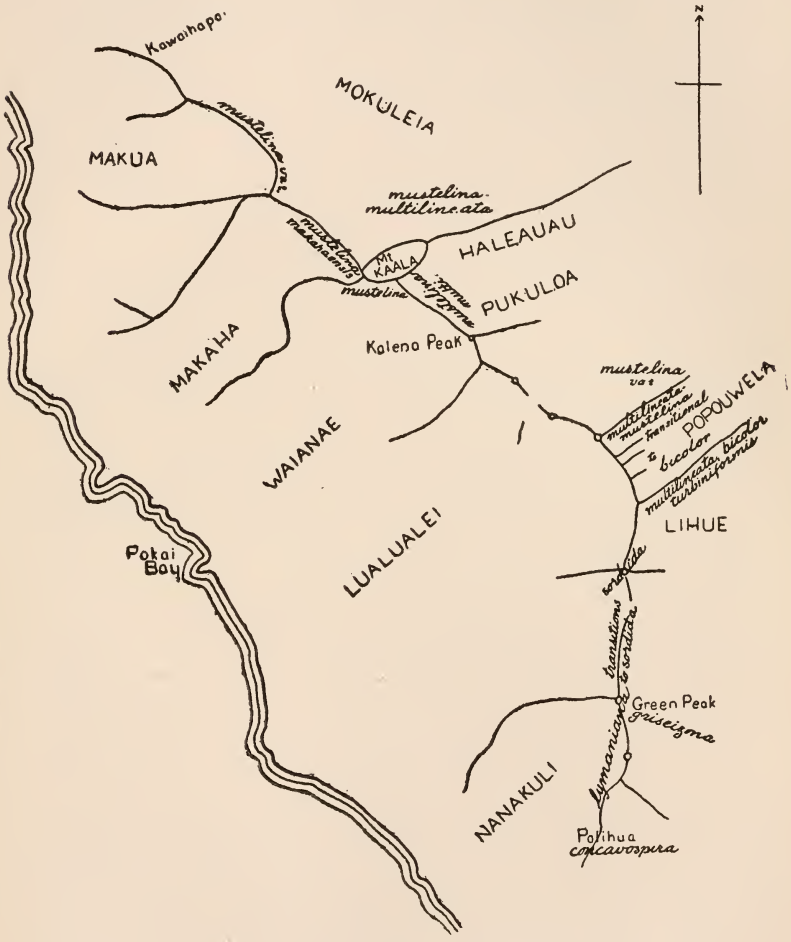
Color and form characteristics and distribution.—On the north side of the range the shells are either blackish-brown with a white subsutural band (*mustelina* pattern), or of various shades of drab or vinaceous buff, more or less streaked, with or without spiral lines or bands (*multilineata* pattern). My very limited experience in the Waianae range leads me to believe that as a general rule the dark forms are lower, the light and banded higher on the ridges, although the transition is gradual, and probably no colony of dark shells is pure. In the west (Mokuleia, etc.), the white sutural band is quite narrow. Eastward it becomes broader, culminating in the *bicolor* pattern of Lihue. In the middle section of the range (Haleauau, Popouwela) the white sutural band is intermediate in width. Properly speaking, no line can be drawn between typical *mustelina* and *bicolor*; and both, in their respective districts, merge directly into *multilineata-monacha* and bandless patterns of various tints.

It appears thus that there has been some differentiation *vertically,* and more *horizontally,* along the range; but the continuity of the forests has favored migration, so that from the systematic standpoint, *bicolor, multilineata* and *monacha* cannot well be defined as races distinct from *mustelina,* though in dealing with particular colonies some subvarietal nomenclature may eventually be needed.

A. mustelina with its several forms already mentioned does not extend southeastwardly beyond Lihue. From there to the end of the range it is replaced high on the ridge by two quite diverse races: *A. m. lymaniana,* an invariably sinistral shell, which connects with *mustelina* through the forms called *sordida* and *napus;* and *A. concavospira,* a dextral form of rather lighter structure, with the outlines of the spire usually more concave.

A. concavospira is the terminal member of the series southeastward; and although in some colonies there is an approach to the *mustelina* (*multilineata* or *napus*) shape and coloring, yet the differentiation as typically developed may be sufficient

ground for allowing it specific rank, as a working arrangement. *A. concavospira* does not seem directly related to *lymaniana,* which inhabits the same district, but rather to the



SKETCH OF WAIANAE RANGE, THE PRINCIPAL RIDGES REPRESENTED BY LINES.

bicolor stock. The area of *concavospira* and *lymaniana* forms a long and narrow extension of the tree-shell country, which broadens out from Lihue westward.

On the south or Ocean side the range falls so precipitously from the narrow crest that forest is lacking for the greater part. Where the crest is wider, or butresses extend oceanward, there is some shell country on the Ocean side of the summit. I understand that this is the case in the Palihua region, which I did not visit. Otherwise, the only tree-snail forests on the south side are in the heads of the valleys under the butresses and peaks. In the head of Makaha there is a modified form of the Mokuleia *mustelina,* and a peculiar special race, *A. m. makahaensis.* In the head of Waianae valley, under Kaala, I am informed that *mustelina* occurs.

Further east the valleys of the south side look very arid, and no tree snails have been reported. The forms from high on the ridge, *lymaniana* and *concavospira,* have already been noticed.

The distribution of the several races is approximately indicated on the accompanying map.

40. A. MUSTELINA Mighels. Pl. 63; pl. 62, figs. 1, 2.

"Shell dextral, conical, dark brown with a light revolving band at the suture, perforate; whorls 7; convex; aperture oblong; lip simple, acute. Length 1 inch, diameter nine-twentieths inch. *Hab. Waianai*" (*Mighels*).

Oahu: Entire Waianae range, in various varieties.

Achatinella mustelina MIGHELS, Proc. Boston Soc. N. H., ii, 1845, p. 21.—REEVE, Conch. Icon., vi, pl. 3, f. 21.—PFR., Monogr., iii, 458.—THWING, Orig. Descript. Achatinella, pl. 1, f. 9.—*Apex mustellina* Migh., HARTMAN, Proc. A. N. S. Phila., 1888, p. 39.—? *Achatinella vestita* MIGHELS, Proc. Bost. Soc. N. H., ii, 1845, p. 20.—*Achatinella multilineata* NEWC., P. Z. S., 1853, p. 138, pl. 22, f. 23.—*B*[*ulimella*] *multilineata* Newc., HARTMAN, Proc. A. N. S. Phila., 1888, p. 30.—*Achatinella monacha* PFR., P. Z. S., 1855, p. 3, pl. 30, f. 9; Monographia, iv, 522.—*Achatinella monarcha* Pfeiffer, THWING, Orig. Descript., p. 186.

The chief races and color-patterns of *A. mustelina* are as follows:

Form rather stout; spire with slightly concave or straight outlines.

Pinkish, sutural band white, *makahaensis*.

Carob-brown to ashen, with a moderate or narrow sutural white band, *mustelina* pattern.

Many dark bands on a paler ground, *multilineata* pattern.

Upper third of last whorl white, lower part blackish-brown, *bicolor*.

Form more slender, spire straightly conic.

Fawn to white, usually banded, white below suture, *sordida*.

Carob-brown with speckled streaks of white; often banded; sometimes ochraceous or whitish; sutural white band usually linear; sinistral, *lymaniana*.

The original descriptions of synonyms of *mustelina* follow.

A. multilineata Newcomb. Pl. 29, fig. 23, reproduction of the original figure. "Shell dextral or sinistral, solid, elongately conical; whorls 6, rounded, margined above; lip expanded below, and slightly subreflected, above acute and thickened within; columella short, stout, slightly twisted, with a callus spread over and nearly closing the umbilicus. Aperture oblong-ovate. Color of columella, lip and suture white, sometimes tinged with yellow; shell white, with or without numerous transverse lines of a brown or black color. Length nineteen-twentieths, width ten-twentieths of an inch. Koolau poco, Oahu.

"This species makes a near approach to *A. mustelina* of Mighels, but is more elongate in form, with the lineations much stronger, and never passes into the variety of *mustelina* with the depressed spire and obese body-whorl. The locality also is different, which is always worthy of particular remark when examining shells of this genus" (*Newcomb*).

The locality given by Dr. Newcomb is certainly erroneous. No shell of this section, except *A. lorata*, is known to occur on the Koolau slope. Newcomb's shell is well known to be from the Waianae mountains, and probably the type came from Mokuleia district, where it occurs in *mustelina* colonies.

Achatinella monacha Pfr. Pl. 30, fig. 9, photographic copy of the original figure. "Shell imperforate, ovate-conic, solid, obliquely striatulate, little shining; gray-white, variously encircled with brown lines; spire elevated-conic, a little acute;

suture lightly margined, subcrenulate; whorls 6, a little convex, the last a little shorter than the spire, rotund at base. Aperture oblique, broadly obauriform; columellar fold above, oblique, moderate; peristome sublabiate, the right margin narrowly expanded, columellar margin thick, flexuous, adnate. Length 20, diam. 10½ mm.; aperture 9½ mm. long, 5 wide. Inhabits Sandwich Islands, Frick'' (*Pfr.*).

This is merely a multilineate form of the grayish *mustelina*, similar to *multilineata* Newc., but based upon a shorter form than that.

Achatinella vestita. Shell sinistral, acuminate-conical; light brown or white, with beautiful narrow dark brown bands, more or less numerous; imperforate; whorls 6, convex; aperture semilunate; lip reflected. Average length 1 inch, diameter ½ inch. *Hab.* Waianai and Hawaii (*Mighels*, Proc. Boston Soc. of Nat. Hist., ii, 1845, p. 20).

If really from Waianae this would, we suppose, be *multilineata* Newc. Several of Mighels' localities are certainly false, and as the type of *vestita* was destroyed by fire, we can only drop the species as impossible to identify positively. We are the more willing to do this because *vestita* has page-priority over *mustelina*, and we feel unwilling to give up a name which has been identified with certainty for one to which some doubt attaches.

Mokuleia.—The typical form of *mustelina* is that found in Mokuleia district, in the northwestern flank of the Kaala mass. The typical color, pl. 63, fig. 5, is a deep shade of carob-brown or blackish chestnut brown, the embryonic whorls white, pale brownish towards the apex, or entirely cartridge buff. The dark color begins on the fourth or fifth whorl. The lip is thickened within as usual, and is either vinaceous buff or nearly white. Shell either dextral or sinistral. The size assigned by Mighels, ''1 inch,'' was probably approximate, as the largest Mokuleia specimen I have seen is a little over eighteen-twentieths of an inch. A more usual size is length 21, diam. 12 mm.

We do not know that the dark typical color-form occurs in pure colonies. It is associated with shells of a citrine drab

hue, indistinctly streaked with deep olive; also vinaceous buff to nearly white shells with few or many brownish drab, cinnamon or even black spiral lines or bands—a *multilineata* pattern (pl. 63, figs. 4, 4*a*, 4*b*, Mokuleia, close to the N.-W. head of Makua, coll. by Spalding). There may also be various combinations of these patterns in some lots.

Pl. 63, figs. 5-5*b* are Mokuleia specimens from Gulick. Pl. 63, figs. 2, 2*a* are from Newcomb, without locality. Fig. 2 is a very unusual pattern, which I have not seen in any other lot.

On the edge of Makua, along the whole lower length of the ridge, Mr. Spalding found a pure colony of the olivaceous drab form shown in pl. 63, fig. 4*a*. There are also pure colonies of the *multilineata* pattern: pl. 63, fig. 3, western ravines of Mokuleia, coll. by Spalding. In the Gulick collection there are several Mokuleia lots of "*multilineata,*" some running into "*sordida,*" others into the olivaceous drab pattern (pl. 62, figs. 1, 2). Occasional shells are white with some faint dusky purplish stains and no bands.

Makaha.—On the south side of the range at the head of Makaha valley, Mr. Spalding found some peculiar colonies. In the northeastern extreme, under Kaala, pl. 63, fig. 1, the shells are distinctly streaked with various shades of plumbeous, dark olive gray and blackish brown on a white ground, the streaks cut by a number of white spiral lines; sutural margin white. This form is a modification of the more streaked forms found in Mokuleia at the edge of Makua. It exists as a pure race.

Further down, in Makaha, back of the home clearing of the Manager of Makaha plantation, and on the edge of the coffee clearing there is a race in which the tint varies from nearly white with indistinct pale ochraceous salmon streaks, to vinaceous pink; sutural border white. As this is a pure race, it may be distinguished by the name *A. mustelina makahaensis* P. & C. Pl. 62, figs. 3, 4.

Haleauau.—Eastward of the great ridge running northeast from Kaala, in Haleauau, the *mustelina* pattern is modified somewhat by the widening of the white band below the suture. Usually there are light streaks and spi al lines in the dark

color of the last whorl, sometimes producing a real *multilineata* pattern. The embryonic whorls are typical in some lots, the first neanic whorl brown or marked with brown, as in shells taken by Mr. Spalding in the northern ravines of Haleauau; but in a lot from the eastern ridge of Haleauau the embryo is bicolored, ochraceous with a white band below the suture, the tip fleshy. Pl. 63, figs. 6, 6*a* from the Thaanum collection. Most lots from Haleauau include both dextral and sinistral shells.

Pukuloa.—Several colonies where Mr. Spalding collected, Pukuloa, between Mikalua Gap and Pukuloa, and on Kalena Peak, have forms resembling those of the western ridge of Popouwela, plain or multilineate, the sutural border sometimes as narrow as in Mokuleia. Also specimens approaching *bicolor* by widening of the sutural white band.

On the Leilehua-Waialua division ridge the colony found was all dextral, with a more or less dark basal tract not extending to the periphery (pl. 63, fig. 7, coll. by Spalding). In a colony from the same neighborhood, but nearer Kaala, no. 1646 of Spalding's collection, there are a few sinistral shells; very few have a dark basal patch.

Popouwela.—On the western ridge the shells are mainly sinistral,—43 sinistral to 14 dextral in one lot I collected. The embryonic whorls are bicolored, the upper half of each buff, lower half white, or rarely they are all ochraceous or all very pale buff, the tip is always slate-violet. The last whorl is wood brown to light buff or almost white, with faint oblique darker striæ and olive-brown spiral lines and bands, or rarely very dilute purplish-gray bands (pl. 63, figs. 9-9*b*, northern colony of the western ridge of Popouwela). Further up the ridge there are more white shells with faint or pale neutral gray streaks, with or without blackish spiral lines (pl. 63, figs. 8, 8*a*).

Pl. 63, figs. 10 to 10*c*. Near the foot of the third small ridge eastward there is a large colony in which the color is Mars brown with blackish bands and a wide, snow-white sutural band, occupying half of the penultimate whorl. Only 18 in 173 found by me are dextral. Among the dark shells are

about half a dozen as light as the banded form from the western ridge. Fig. 10 is a very unusual color-pattern in this colony, and figs. 10*b*, *c* show extremes of shape but normal coloring.

In a small area of probably two or three square rods we found snow-white shells with the columella dull lavender or white, summit white. This is evidently a recent albino mutation which has not had time to spread far. They occur with the ordinary pattern of the surrounding colony. The specimens I found were all dextral.

Further up the same ridge the shells are intermediate in pattern between the preceding colony and that of the western ridge of Popouwela.

A colony in coll. Spalding from the "southern ridges of Popouwela" varies from the patterns of pl. 63, figs. 12, 12*a* to black with white bands or white flecks, resembling the *lymaniana* pattern. One is figured, pl. 63, fig. 11.

On the Popouwela-Lihue division ridge Mr. Spalding found a dextral and sinistral form like that shown in pl. 63, fig. 10*c*, except that the white sutural band is a trifle wider. With them, without intergrading specimens, there is a smaller form closely resembling *turbiniformis*, but with less concave spire, pl. 62, fig. 21. This may be regarded as the western limit of the *turbiniformis* stock. The shells are dextral, and from their smaller size, different coil and markings, probably do not hybridize with their larger dark companions.

Further up the same ridge, Mr. Spalding took lighter bicolored shells with others of *multilineata* pattern (pl. 63, figs. 12, 12*a*).

It appears that between the main northeastern ridge from Kaala and the Popouwela-Lihue ridge, the prevalent form is a shell with the white sutural band wider than Mokuleia *mustelina* on the west, and *narrower* than Lihue "*bicolor*," eastward. The darkest forms are near the lower limit of shell country, while on the higher ridges the lighter, *multilineata* patterns prevail; but there are exceptions. It will be noted that in the Main Range banded forms are also chiefly developed on the ridges.

Lihue.—This is a district of somewhat indefinite limits, where Gulick, Newcomb, and other naturalists of their day collected, on the east and southeast slopes from Kanehoa. Indeed, Lihue ("Lehui") and Mokuleia seems to have been the chief sources of their Waianae shells.

In the large Lihue series before me from Gulick the *mustelina-multilineata* forms have a wide sutural white band, as in Popouwela. They vary widely in size, from 18½ x 10 to 20½ x 13⅓ mm., and a few have the *turbiniformis* contour. They have linear streaks of fawn on a buff ground, with or without dark and light spiral lines or bands. Pl. 63, fig. 13*d* is a slender shell of this series, others of the Gulick lots are figured on pl. 61, figs. 7, 7*a*. They resemble the Popouwela shells, and also, in some specimens, are remarkably like *A. decora*.

A. m. bicolor 'Gulick' Pfeiffer is typical of Lihue. Pl. 63, figs. 13 to 13*c*, Gulick collection. It is chestnut-brown to blackish carob-brown below, white above. Typically the white should extend almost to the periphery, and leave a mere line of dark brown above the suture, but in the series of over 200 before me, this ideal is rarely attained. The white band commonly varies from 1½ to 4 mm. wide on the last whorl. The sutural border is often tawny. The summit is warm or ochraceous buff, paler or dusky at the tip, and often has paler bands on the last embryonic whorl. Figs. 13*b*, 13*c* show unusual extremes of shape. With the lots of *bicolor* there are a few shells transitional to the pattern shown in pl. 61, figs. 7, 7*a*. Probably the *bicolor* occurs low, the lighter form higher on the ridges, with more or less admixture in the colonies. The original description of *bicolor* follows.

"*A.* [*chatinella*] *bicolor* 'Gulick' Pfr. Shell subperforate, globose-conic, solid, lightly striate, glossy; whitish, obliquely streaked with brownish; spire conic, with rather acute apex, white; suture broadly impressed-marginate; whorls 5½, the upper ones flat, penultimate more convex, the last nearly equal to the spire, globose, black-chestnut below the periphery. Aperture oblique, subauriform; columellar fold high, nodiform; peristome labiate within, brown-bordered, the right margin narrowly expanded; columellar margin dilated, subadnate. Length 16½, diam. 11 mm.; aperture 8½ mm. long, 5 wide. Inhabits Lehui, island of Oahu" (*Pfr.*).

A. bicolor Gulick in Mus. Cuming, Pfr., Monographia Heliceorum Viventium, iv, 529, 1859. It was never described by Mr. Gulick.

40*a*. A. MUSTELINA SORDIDA Newcomb. Pl. 30, fig. 27; pl. 62, figs. 5-11.

"Shell elongately conical, solid; whorls 7, slightly rounded, margined above; aperture small, somewhat contracted; lip subreflected below, acute above, thickened within; columella short, slightly twisted, with an expanded callus partially covering a shallow, small umbilicus; color variable, with a white ground variously banded and striped transversely with brown or black. Length eighteen-twentieths, width nine-twentieths of an inch" (*Newcomb*).

Oahu: Lettui [Lihue] (Newc.).

Achatinella sordida Newc., P. Z. S., 1853, p. 139, pl. 23, f. 27.—Pfr., Monogr., iv, 523.—*Achatinella napus* Pfr., P. Z. S., 1855, p. 5, pl. 30, f. 19; Monogr., iv, 534.—*Cf.* Newcomb, Ann. Lyc. N. H. of N. Y., vi, p. 308.

The original figure is reproduced in pl. 30, fig. 27.

This race differs from *turbiniformis* and *concavospira* by its less convex whorls and straight-sided spire; from *mustelina-bicolor* by the more slender contour. It varies a good deal in color—from fawn or Vandyke brown with a white sutural band to white with some faint tawny suffusion or lines towards the base. I understand that it occurs high on the ridge, between the area occupied by *mustelina* and *bicolor* and that of *lymaniana* and *concavospira*. There are transitional forms between *sordida* and *lymaniana*.

A. m. sordida is usually sinistral, but sometimes has a dextral form, which was described as *A. napus*.

"*A. napus* Pfr. [pl. 30, fig. 19, reproduction of original figure]. Shell imperforate, dextral, turrited, solid, striatulate, a little shining; whitish, encircled with grayish-fleshy bands and sometimes chestnut lines; spire long-conic, apex white, acute; suture distinctly margined; whorls 6½, the upper flat, following slightly convex, the last whorl about equal to one-third the length, rounded; aperture diagonal, truncate-auriform, columellar fold superior, moderate, lightly

twisted; peristome lipped within, the right margin unexpanded, columellar margin somewhat dilated, adnate. Length 19½, diam. 10½; aperture 8 mm. long, 4½ wide. Inhabits the Sandwich Islands, Frick, Mus. Cuming" (*Pfr.*).

This form is considered by Dr. Cooke to be an absolute synonym of *A. sordida* Newc., from which it differs in being dextral and imperforate. Dr. Newcomb thought it an "elongated variety" of *A. pulcherrima.* From this arose Pfeiffer's "*Achatinella pulcherrima var. elongata Newc.*" (Monographia, vi, 172, 1868). Mr. Sykes considers *A. concavospira* Pfr. to be identical with *napus* (Fauna Hawaiiensis, p. 303). The weak convexity of the penultimate whorl and the straight outlines of the spire are common characters of *sordida* and *napus.* Moreover, one of Gulick's lots contains both dextral and sinistral specimens, otherwise similar (pl. 62, figs. 5-8), which seem to demonstrate the identity of the two supposed species. Pl. 62, figs. 9, 10, 11 were drawn from specimens of *sordida* received from Dr. Newcomb.

40*b*. A. MUSTELINA LYMANIANA Baldwin. Pl. 61, figs. 8-9*b*, 11.

"Shell sinistral, very minutely perforated, solid, ovate; spire convexly conical, apex subacute; surface shining, covered with fine incremental lines, under a strong lens showing minute decussating striæ; apical whorls smooth, when not eroded. Color dark purplish brown, sometimes with longitudinal or transverse white flecks or zigzag lines; a white line traversing the suture; apex light chestnut. Whorls 6, very lightly margined above, somewhat convex; suture moderately impressed. Aperture oblique, white within, sublunate; peristome acute, thickened within, expanded, the columellar margin slightly reflexed and covering the small perforation, color white on both face and the reverse; columella white, terminating in a slightly developed flexuous fold. Length 20½, diam. 11½ mm." (*Baldwin*).

Oahu: near the southern end of the Waianae range, from around Green Peak (Palikea), three or four miles along the ridge southward, only at high elevations.

Named for Mr. Ernest Lyman. Types in the Baldwin collection.

This is a well-marked subspecies, always sinistral, solid, with long, straightly conic spire, *the sutural white band narrow, usually reduced to a mere line,* or sometimes absent. The typical pattern is carob-brown with speckled white streaks, more or less interrupted by spiral lines or bands of the dark color, or reduced to a few whitish flecks on a blackish carob-brown ground (figs. 8 to 8*c*, Palihua iki, coll. by Dr. C. M. Cooke).

Another pattern, from the same locality and collector, is ochraceous tawny, with streaks and spiral lines of warm buff, a pale line at the suture or none (fig. 8*d*).

Other shells of this lot are cartridge buff, almost white, with the faintest traces of pale ochraceous salmon bands, fig. 8*e*.

Length 23.8, diam. 13.2 mm.; 6½ whorls.

Length 22.5, diam. 13.5 mm.; 6½ whorls.

Length 20, diam. 10.3 mm.; 6½ whorls.

The typical forms of *lymaniana* occur along the ridge south of Green Peak. North of Green Peak it is mixed with forms with the *napus* pattern,—buff with a few wide dark bands, the shell sinistral—probably in a hybrid colony. Specimens from the Lihue side, under Palikea, are figured, pl. 61, figs. 9 to 9*b*, coll. by Spalding. Pale forms of *lymaniana* pass into *sordida Newc.*, so that there seems to be no definite distinction between selected individuals although there may be a difference in the average constitution of the colonies.

It is also likely that some adumbration of the *lymaniana* stock has penetrated as far north as the southern ridges of Popouwela, forming hybrids with the gray and banded *mustelina* there. Pl. 63, fig. 11 has the appearance of being a *lymaniana* segregate of this stock, and there are others in the collection before me.

41. A. CONCAVOSPIRA Pfeiffer. Pl. 52, fig. 16; pl. 61, figs. 12-12*d*; pl. 62, figs. 24, 25.

"Shell subperforate, dextral, ovate-turrite, solid, striatu-

late, glossy; whitish, ornamented with bands and narrow streaks of coffee color. Spire concavely turrite, the apex somewhat acute, white; suture strongly margined. Whorls 7, the first three flat, following whorls convex, the last one rounded, about equal to two-fifths the length. Columellar fold superior, nodiform, white. Aperture oblique, reversed auriform; peristome liver colored, the right margin a little expanded, columellar margin very much dilated, reflexed, adnate. Length 21½, diam. 11⅓ mm. Inhabits Sandwich Islands, Dr. Frick, in Mus. Cuming'' (*Pfr.*).

Palihua and Palihua iki, at the extreme southern end of the Waianae range; the form *turbiniformis* in Lihue and on the Popouwela division ridge.

Achatinella concavospira Pfr., Proc. Zool. Soc. Lond., 1859, p. 30; Monographia, vi, p. 169.—*Apex turbiniformis* Gulick, P. Z. S., Lond., 1873, p. 81, pl. 10, f. 7.

A. concavospira with its several races is always dextral, so far as we know, thereby differing from *A. m. lymaniana* of the same district, which is invariably sinistral. Where *A. c. turbiniformis* occurs in the same colony with *A. m. bicolor* on the Popouwela-Lihue division ridge, there are no intergrading specimens (*cf.* no. 646, 647 coll. Spalding). It appears that where *concavospira* forms occur with various subspecies of *mustelina*, the two retain fully the proper shape, size and color of their respective species, and the inference may be drawn that they do not hybridize, at least ordinarily. My attention was not specially directed to this point when studying the Honolulu collections, but the material I brought home and possess from the Gulick collection leads me to segregate *concavospira* specifically.

The type-specimen of *A. concavospira* as represented in pl. 52, fig. 16, which I owe to the kindness of Mr. E. A. Smith, and typical shells such as Mr. W. D. Wilder collected in Palihua at about 3,000 ft. elevation, pl. 62, figs. 24, 25, is a strikingly distinct form, differing from *A. mustelina.* by its very concave-sided slender spire and the short, swollen, last whorl. The 3½ embryonic whorls are flattened, white or a little fleshy towards the tip. Subsequent whorls a little over three, the

first one slightly, the last two *very convex.* All are deeply margined below the suture, the margin at first brown or tinted, often becoming white later. The last whorl is marked with bands of carob-brown or tawny, and sometimes tawny streaks, on a white or warm buff ground, the markings mainly on the base, and deepening as they approach the lip. The aperture is white within, lip deep brown, slightly expanded and thickened within. All seen are perforate and dextral.

Length 19¼, diam. 11⅓ mm.; aperture 9 mm.

Length 19, diam. 10½ mm.; aperture 8.9 mm.

In a lot from Palihua (pl. 61, figs. 12 to 12*d*, coll. by C. Montague Cooke) this typical form passes into almost the *mustelina* shape, with varied coloring. The dimensions are remarkably diverse, from length 20, diam. 11.3, aperture 9 mm., to length 20.2, diam. 12.5, aperture 10.8 mm. This lot connects typical *concavospira* with the following.

A local form or subspecies of *concavospira,* which may be called *griseizona* P. & C., was found by Dr. Cooke in Palihua iki. The colony, which is very uniform, extends over ten or fifteen acres of lantana, at the head of a small valley running north. The shells, pl. 61, figs. 10, 10*a*, 10*b*, are rather stout in figure, the outlines of the spire decidedly to very slightly concave. The marginal furrow below the suture is less emphatic than in typical *concavospira,* and appears on 2½ whorls, instead of over 3 as in *concavospira.* The apex and embryonic whorls are white; there is no sutural color-band on the early neanic whorls; the later whorls have fawn bands, more or less streaked and overlaid with white, producing various shades or tints of brownish drab, pale Quaker drab or pale violet gray. The lip is white or dull brownish. There are 6¼ to 6½ whorls, the penultimate whorl much less convex than in *concavospira.* This form has the coloration of *napus.*

41*a*. A. CONCAVOSPIRA TURBINIFORMIS Gulick. Pl. 62, figs. 22, 23.

"Shell dextral, subperforate, subglobose-conic, a little shining, striated with growth lines but hardly spirals, white, encircled around the base with a few brown transverse lines;

suture distinctly margined; spire lightly concave; whorls 6, the first three a little convex, the rest convex. Aperture white; peristome with a thin margin, bordered within with dilute brown; columellar fold moderately strong. Length 17, diam. 11 mm." (*Gulick*).

Oahu: Kalaikoa and Lehui [Lihue], on trees (Gulick).

"It is allied to *A. tuberans* Gk., but has a much narrower spire. All the specimens found are dextral. The shell figured is from Lehui" (*Gulick*).

Gulick's figured type from Lihue is drawn on pl. 62, figs. 22, 23, no. 102 Boston Soc. coll. The locality "Kalaikoa" is probably an error. It is possible though not probable that under long past conditions it extended across the central plain, as some Amastras have done. However, *turbiniformis* has the look of a shell from high on the ridges. It is, in fact, merely a shortened form or local subvariety of *concavospira,* which is a high altitude shell.

The apex and embryonic whorls are white in the specimen selected by Gulick as type. It was a dead shell. The last embryonic whorl is weakly plicate axially, as in some typical *concavospira.* The sutural margination of the post-embryonic whorls is strong, and faintly touched with brown along the sutural edge on the last two whorls, perhaps further up, in life, the spire of the type appearing somewhat faded. The penultimate and last whorls are particularly convex, last whorl short, swollen, with a pattern of interrupted oblique streaks and narrow spiral lines of brown, chiefly on the base, but near the lip the pattern extends upward nearly to the suture. The narrow lip-callus stops a few millimeters short of the suture, as in typical *concavospira.* Length 16, diam. 11, length of aperture 8 mm.; 6½ whorls.

Mr. Spalding collected *turbiniformis* on the Lihue-Popouwela division ridge, in a prolific colony of *bicolor,* both preserving their individuality. It occurs for some distance up the ridge. One of this lot is figured, pl. 62, fig. 21.

APPENDIX I.

ADDITIONAL NOTES, AND NEW SPECIES OF ACHATINELLIDÆ.

Genus NEWCOMBIA Pfr.

This volume, page 1. The word *sinistral* should be added to the generic diagnosis.

N. pfeifferi and *cinnamomea* live chiefly on the bark of small trees where they stick twig-like, often in a fork, and are hard to see. *N. plicata* has the same habit.

N. sulcata and *gemma* live on leaves, according to Mr. Thaanum. *N. canaliculata* lives on lehue and lantana.

NEWCOMBIA PLICATA (Migh). Page 3. Add the localities: Waialue (Thaanum); small trees overhanging the pali at top of Leper Settlement trail (Cooke & Pilsbry).

NEWCOMBIA PFEIFFERI (Newcomb). Page 13. This form does not occur at or near Puu Kolekole (a locality for *cinnamomea*), and that locality should therefore be deleted. Dr. Cooke and Mr. Thaanum hold that *pfeifferi* and *cinnamomea* are extremes of one species; a view which their collections support. The subspecies called *ualapuensis* Pils. belongs to *pfeifferi* rather than to *cinnamomea*. The distribution of the forms is rather peculiar. Beginning at the eastern valleys and going westward, the forms are encountered thus:

Honomuni ..... *honomuniensis.*
Ahaino ..... *decorata.*
Kupeke ..... *decorata.*
Pukoo ..... fossil *cinnamomea* (Thaanum).
Mapulehu ..... *cinnamomea.*
Kaluaaha ..... *pfeifferi.*
Ualapue ..... *ualapuensis.*
Kahaanui ..... *ualapuensis.*
(Several valleys ..... wanting.)
Makolelau ..... *cinnamomea.*
Makakupaia ..... *cinnamomea.*

It will be seen that east of Kaluaaha there are only smoothish variants of *cinnamomea;* west of Kahaanui a long series of parallel valleys and ridges supervenes in which no allied form has been found, *cinnamomea* appearing again in Makolelau in a ravine east of the house, and in a small ravine east of Puu Kolekole (Cooke & Pilsbry), and further west in Makakupaia.

Where the connection between the eastern and western herds finds place, if at all, is not clear, as we saw nothing of the species in the region above the Kamalo amphitheatre, where Thaanum and others also have collected.

N. PHILIPPIANA Pfr. (*perkinsi* Sykes). Antea, pp. 8, 9.

It is interesting to find that this most primitive of existing Newcombias occurs in the Pleistocene shell-beds of Moomomi (Cooke & Pilsbry, 1913). Like the other tree-shells of the dune deposits, it is rather rare.

Genus PARTULINA Pfr.

Section PERDICELLA Pease.

P. ORNATA (Newc.). Page 18. By an oversight the locality was given as East Maui. Very beautiful specimens have been taken by Mr. Thaanum on Mt. Helu and Mt. Lihau, both in West Maui. The only other locality known is that given by Newcomb.

P. HELENA (Newc.). Pl. 54, figs. 1-3.

Page 16. The quotation from Newcomb on p. 17 might give a false idea of the abundance of this species. It is a common shell on shrubs of many kinds, from the head of Kamalo to the region of Puunea, at the present western limit of tree-snails; found only on the high part of the island, of course. No doubt Newcomb's type was from the Puunea region, somewhere between Meyer's place and the north cliff.

Different colonies, even in the same neighborhood, are often unlike in markings. Thus, on the margin of the flat north of Meyer's lake the patterns of pl. 4, figs. 1-5 prevail, but there are also a few of the *balteata* pattern, similar to pl. 4, fig. 7.

No blends between the normal pattern and *balteata* were noticed.

In another colony, west of Meyer's lake, the markings are bolder and there is no whitish belt. The oblique-striped pattern is usually more dislocated than in pl. 54, figs. 1, 1*a*, but it always gives place to a vertical striping on the latter part of the last whorl.

On the flat east of the peak of Puukolekole the majority of specimens have the pattern of pl. 54, fig. 3, but about one-third are cinnamon-buff with a dark peripheral band, bordered below with a white band, pl. 54, fig. 2. This is very much the color of the normal embryo shell, in the first half of the third whorl.

The several stages of the color-pattern are rather well-marked in *P. helena,* and deserve further study.

P. THWINGI P. & C., n. sp. Pl. 54, figs. 6, 6*a*, 6b.

The shell is dextral, perforate, ovate-conic, moderately solid. White, profusely maculate and mottled with mummy brown, under the lens showing a few ochraceous spots or streaks, the periphery marked with a narrow dark band, a cream-white band below it. The last embryonic whorl has forwardly-descending stripes of dark brown and white; summit pale. Surface not glossy, under the lens rather distinctly marked with spiral and descending, waved striæ, and irregular growth-lines. Spire straightly conic, tapering to a subacute apex. Aperture pallid purplish-gray and brown within; outer lip with a pale acute edge, unexpanded; basal lip slightly expanding, the columella slightly brown-tinted, having a rather strong, callous fold above; the edge reflected close to the insertion.

Length 17, diam. 9.8, aperture 8 mm.; 6⅓ whorls.

Length 16, diam. 9 mm.

East Maui: Auwahi, D. Thaanum. Cotypes in coll. A. N. S. P. and Bishop Museum. Also in Thaanum collection.

One of the largest *Perdicellas,* notable for its straightly conic, rather slender spire, and the particular color-pattern. The dark peripheral band, bordered with a white one, is in-

variable in the series examined. The pattern of longitudinal zigzag stripes is distinct in places, or the stripes have been so dislocated that usually a mottled effect is produced. In both color and shape it has some resemblance to *P. grisea* Nc., which differs by being sinistral, larger, with a different pattern of color on the embryonic whorls, and a less prominent columellar fold. *P. carinella* has much the same general color, and no doubt is somewhat related.

Named for the Rev. E. W. Thwing, whose compilation of the original descriptions of *Achatinellidæ* has been a useful handbook for Hawaiian conchologists. The large collection made by Mr. Thwing now belongs to the Bishop Museum.

PARTULINA CARINELLA (Baldwin). Page 7.

This species is undoubtedly a *Perdicella,* as Dr. Cooke and Mr. Thaanum have pointed out to me. It should be removed from *Newcombia,* which without it consists wholly of sinistral species.

Section PARTULINA.

PARTULINA VIRGULATA (Migh.). Page 25.

This species inhabits the eastern part of Molokai, almost one-third of the island's length; from Pelekunu and the first valley northwest of Kamalo to the eastern end of the island. Mr. Thaanum, who has had wide experience with the species, finds that eastward of Waialua individuals are sinistral in great majority. Out of 1,067 collected by him, 1,053 are sinistral, 14 dextral. West of Waialua the banded (typical) form is almost always dextral, while the plain or faintly banded form (pl. 26, figs. 1, 1*a*, Mapulehu, coll. by Thaanum) is sinistral, though both may be found on the same tree. The factors for plain coloring and sinistral coil are evidently linked in inheritance.

In the first valley west of the heads of Kamalo, just above the irrigation ditch, east of the stream, the authors found a small, well-banded form of *virgulata* about 21 mm. long. This is probably the extreme western limit. Typical banded *virgulata* was taken by Thaanum in Honouliwai, a place far eastward, not before recorded.

A. virgulata halawaensis 'Baldwin' Borch. Pl. 26, figs. 2, 2*a*, Kepookoholua, coll. by Thaanum, seems to be rather a "good" subspecies by its slender form, pale color, with narrow bands or none. It is found only in the Halawa district. In general, *P. virgulata* is darkest westward, lighter towards the east, though there are individual exceptions.

P. VIRGULATA KALUAAHACOLA n. v. Pl. 26, figs. 3, 3*a*.

The shell is small, sinistral; embryonic whorls white with a blackish-chestnut band above the suture; subsequent whorls closely marked along growth-lines with hazel lines on a warm buff ground, or with indistinct brownish streaks and some hazel lines on a tawny olive ground; indistinctly banded. Length 19.5 to 20 mm.

Kaluaaha, at about 1,700 ft., on ieie. D. Thaanum.

This is a local race, related to the plain form of *virgulata* figured on pl. 26, figs. 1, 1*a*. It occurs at the lower limit of tree shells in this valley, and is extremely rare—perhaps now extinct.

P. SUBPOLITA Hyatt & Pilsbry, n. sp. Pl. 23, fig. 1.

Shell imperforate, sinistral, ovate-conic, rather solid. Embryonic whorls white with a broad chocolate band above the suture, having excessively faint spiral striæ or none. Following whorls light chrome ("pinard yellow"), uniform or having one or several faint whitish lines at or below the middle. Surface glossy, with distinct wrinkles of growth but only faint traces of spiral striæ. Last whorl somewhat compressed peripherally. Aperture white, the outer lip expanded below, a little thickened within; columella white, fold moderate. Length 17, diam. 11, aperture 9 to 9.2 mm.

Molokai: Ualapue, Thaanum. Cotypes no. 106992 A. N. S. P. and 1932 Cooke coll.

[*Partulina*] *subpolita* P. & H., Manual xxii, p. 24, 1912.

The color pattern of the embryo and the slightly expanded lip allies this to *P. virgulata*, and it stands nearest to *P. v. kaluaahacola* from a neighboring locality. This relationship, pointed out to me by Dr. Cooke and Mr. Thaanum, became

obvious on seeing the superb series of *virgulata* in Mr. Thaanum's collection. It is distinct from *P. polita* by its broad, short spire, sinistral coil, expanded basal lip and white mouth. Four specimens in coll. University of Wisconsin, two in the Cooke collection, one in that of the Academy and several in Mr. Thaanum's collection are essentially alike. It is one of the rarest Molokaian shells.

PARTULINA TESSELLATA (Newc.). Page 28. Taken abundantly in Puunea ("Puanea" of Borcherding's map) at about the western limit of the species; also at the "Pig Wallow" flat above the pipe-line trail, Puulua, Kaunakakai, Cooke and Pilsbry, January, 1913. Eastward it barely reaches the *virgulata* territory.

PARTULINA RUFA (Newc.). Page 29. Newcomb's type figure. is copied photographically in pl. 29, fig. 3.

PARTULINA PROXIMA (Pease). Page 32. In the *redfieldi* colony of the heads of Kamalo we found several *proxima* pure white except for the purple columella. Thaanum found a small form *all with pale green-yellow ground* in Kamalo in 1906, on the same trees from which he had collected normal (white ground) *proxima* in 1894.

We took normal *proxima* on the east side of Puukolekole, in the *P. dwightii* colony. Some of Thaanum's series from Kawela are very small, length 18.5 mm.

P. proxima multistrigata Pils., page 34, is evidently, as Mr. Thaanum holds, a western subspecies of *proxima,* and not of *theodorei.* It has been collected in some abundance in Kalamaula by Mr. Thaanum. This is probably the original locality. *P. theodorei* has not been found so far west.

PARTULINA THEODOREI Baldwin, page 33. Another habitat of this apparently valid species is Makakupaia, recorded by Borcherding, from shells collected by Mr. Meyer. This is westward from Baldwin's locality Kawela. Probably all the records from Kawela rest ultimately upon Meyer's authority.

PARTULINA DWIGHTII Newcomb. Page 35. Pl. 26, figs. 5*b* to 5*f*.

This species is very closely related to *P. redfieldi,* but of

more pyramidal shape with broad white lip-border and white columella, while in *redfieldi* the last whorl of the shell is larger and the lip and columella are dark. *P. dwightii* is a western, *P. redfieldi* an eastern species. Puukolekole, where we collected a couple of hundred in a colony on the eastern side, is about the eastern limit of *dwightii*. In this colony we found a few real *redfieldi* (pl. 26, figs. 5, 5*a*), forming about 16 per cent of the whole. The two species overlap in this district, and it can hardly be doubted that they form hybrid colonies, segregating into the brown- and the white-lipped forms.

Westward, *P. dwightii* is not known farther than Makakupaia, to my knowledge; but it formerly extended as far as the summit of Manuna Loa, and Moomomi on the north coast, in a slightly modified form, described below.

The Puukolekole colony is illustrated in pl. 26, figs. 5 to 5*f*. It is clear that in this colony the forms called *compta* Pse. and *concomitans* Hyatt are mere color-mutants, and in no sense races. The embryos removed from these shells show that several patterns are often the progeny of one parent.

Partulina dwightii, color-form *concomitans*, has been erroneously referred to as *Achatinella macrodon* by Perkins, Fauna Hawaiiensis I, pt. vi, p. lxvi, 1913.

Var. *mucida* Baldwin. Page 34. Typical *mucida* occurs low down in Kamalo (Thaanum), and also in the type locality, Makakupaia below Puu Kaeha. It is merely a small form or race of *dwightii*. *P. macrodon* Borch. is not a variety but only a color-mutant occurring with *mucida*.

P. dwightii occidentalis P. & C., n. v. Pl. 26, fig. 6.

Smaller than *dwightii*, wider than *mucida*, aperture shorter, the lip less prolonged basally. Length 20.5, diam. 12.6, length of aperture 9.5 mm.

Sand dunes of Moomomi (on the north coast almost due north of Mauna Loa); also summit of Mauna Loa, under stones. Cooke and Pilsbry, 1913.

This Pleistocene variety shows that one time tree snails extended almost to the western end of Molokai. A single frag-

ment was found on the southern rim of the bowl near the summit of Mauna Loa, where no doubt forests survived long after it had disappeared in the neighborhood of Moomomi, where the shell occurs much less than a hundred feet above sea level.

PARTULINA REDFIELDII (Newc.). Pl. 29, fig. 5.

Page 38. Mapulehu specimens agree well with Newcomb's original lot. His type figure is copied photographically on pl. 29.

Var. *kamaloensis* P. & C., n. v. Pl. 26, figs. 4, 4*a*.

Between the branch ravines above the Kamalo amphitheatre and below the old irrigation ditch we collected in three similar colonies of *redfieldii*. The shells were very abundant on leafless and often dead lantana. They are mostly large, capacious, and cinnamon brown to chestnut brown or burnt umber in color, most old ones lighter by weathering and loss of cuticle, sometimes to a dull, pale ochraceous buff tint. Rarely the fresh shells are ochraceous buff, with or without a dark band. Very few shells have numerous dark bands on a pale ground. As the colonies are of considerable extent, and nearly homogeneous in character, it may be well to have a name for this particular race.

Length 27.5, diam. 16.7, aperture 14.2 mm.

Length 25.6, diam. 16, aperture 14 mm.

Length 27, diam. 15, aperture 13 mm.

PARTULINA CRASSA (Newc.). Page 40.

The dull form of *P. crassa* described by Newcomb and in all the older collections was probably found near the western end of Lanai, now a deforested region where they still occur as fossils. In the Koela region the shells are of a fine dark brown color.

P. KAAEANA Baldwin. Page 41. Mr. Thaanum thinks that this may be identical with or a variety of *P. ustulata* Gul. (p. 47). Unfortunately a careful search failed to locate the type of *ustulata* in the Boston Society collection. It seems to be lost. No topotypes are extant, and the *ustulata* from other

localities in Gulick's collection are rather unlike the type figure and description. The question of identity must therefore remain in abeyance.

P. MARMORATA (Gould). Page 42. The original figure of the synonymous *A. adamsii* Newc. is reproduced on pl. 29, fig. 20.

PARTULINA WINNIEI Bald. P. 44. Mr. Thaanum has a dextral specimen.

PARTULINA PERDIX (Rve.). *A. pyramidalis* Gul. (p. 46) seems from Mr. Thaanum's series not to be separable from *perdix*. A synonym is: *Achatinella pyrimidalis* Gul., LYONS, Hawaiian Almanac for 1892, p. 105.

P. 47, top line, for pyramid*ata* read pyramd*alis*.

P. GOULDII (Newc.) Pl. 29, fig. 1.

Page 52. The form I separated as *P. g. perfecta* (p. 54) occurs with typical *gouldii* at Ainaloa, W. Maui (Thaanum), and is apparently not a valid race. Newcomb's type figure of *gouldii* is reproduced photographically on pl. 29.

PARTULINA RADIATA (Gould). Page 49. A series of this species, typical and a paler form, is in the J. S. Emerson collection from "Lahaina." While this locality leaves considerable latitude to a naturalist seeking the shell, it at least indicates the southwestern ridges of West Maui as its habitat. There is a good series in the collection of Mr. W. G. Mazyck of Charleston, some in the U. S. Nat. Mus., and a series in coll. A. N. S. P. It was apparently not uncommon sixty years ago, when Emerson, Newcomb and Gulick were collecting, but may be extinct at the present time.

P. SPLENDIDA (Newc.). P. 51. Pl. 29, fig. 4 (reproduction of the original figure).

P. APTYCHA (Pfr.). P. 54. Pl. 30, fig. 1 (reproduction of original figure).

P. NIVEA (Baldw.). P. 59. Mr. Thaanum found a tawny-streaked form with the typical form at Makawao. It has a faint pale line at the periphery, but no white basal band, otherwise agreeing with "var. *kaupakaluana*." The latter is probably a mere color-form, not a race.

P. DOLEI (Baldwin), p. 60, is rarely found dextral.

P. CARNICOLOR Bald., p. 58, might better be classed as a subspecies of *eburnea*.

P. TEREBRA Newc., p. 61. According to Mr. Thaanum, *terebra-ligneria* forms are all around the head of Iao valley, high up; also on Mt. Helu and Mt. Lihau.

P. TEREBRA ATTENUATA (Pfr.). P. 63. Pl. 30, fig. 12 (reproduction of the original figure).

Section EBURNELLA Pease.

P. VARIABILIS LACTEA Gulick. Page 86.

Achatinella saccata Pfr. is an absolute synonym of the above. Through the kindness of Mr. E. A. Smith I can figure the type-specimen in the British Museum. The original description follows.

Achatinella saccata Pfeiffer. Pl. 54, fig. 4. Shell subperforate, sinistral, turrited, rather solid, striatulate, a little decussated under the lens, glossy, white (*candida*); spire regularly tapering, the apex acute; suture narrowly margined; whorls 6½, rather flattened, the last equal to two-fifths the length, a little convex, the base subcompressed-sack-like; columellar fold high, tooth-shaped, brown or flesh-colored; aperture very oblique, semioval, the base laterally produced, inside pale rosy; peristome simple, unexpanded, the columellar margin dilated, somewhat free. Length 21, diam. 9½ mm. Sandwich Islands, Mus. Cuming (*Pfr.*).

Achatinella saccata PFR., Proc. Zool. Soc. London, 1859, p. 30; Monographia Hel. Viv., vi, 175.—*Eburnella saccata* Pfr., PEASE, P. Z. S., 1869, p. 647.

The slight roughness of the figure is due to the process of reproduction.

Section BALDWINIA Ancey.

The species are most numerous in northern Hawaii, but extend more than halfway down the island, on both sides. The colonies, except in Hamakua district, are extremely rare and isolated. Their locations on the island may be represented thus.

horneri
physa
confusa

horneri
konana errans

P. HORNERI (Baldwin). Page 107.

On p. 108 the color-varieties of this species have been described. On going over the series sent by Mr. Thaanum it seems worth while to emphasize the perfectly constant differences by applying names to the forms. If they are always found in pure colonies, as seems to be the case, these patterns have a racial value. In any case, the names will be useful in discussing the composition of colonies.

The typical *horneri* has a broad peripheral band, a small umbilical patch and an inconspicuous subsutural band (often faint in the adult stage), of light ochraceous buff (pl. 17, fig. 1). These bands are all present in the embryonic stage, pl. 54, fig. 11. It will be noted that the peripheral band extends above the peripheral angle.

Var. *candida*. Pl. 17, figs. 3, 4; pl. 54, fig. 12, embryo. (= var. *c*, p. 108.) The peripheral band of the embryo is narrower, and does not extend above the angle. There are no other bands on the cream-white shell.

A small form of *P. h. candida* has been found at Honoula, N. Kona, and sent by Dr. Cooke. The peripheral band persists longer than in Kukuihaela shells, being visible on the front of the last whorl. The spiral striation is a little stronger. Length 18-19 mm.

Var. *fuscospira*. Pl. 54, fig. 13, embryo (= var. *d*, p. 108). Embryo cinnamon below, light buff above the periphery, a white line below the suture.

Var. *fuscozonata*. Pl. 17, figs. 2, 5 (= var. *b*, p. 108).

P. PHYSA KONANA P. & C., n. subsp. Pl. 54, figs. 5, 5*a*.

The shell is smaller than *physa*, thin; periphery marked with a brown band; above this it is zigzag-streaked with brown and cream-white, the pattern usually confused on the last

whorl, distinct on the penultimate; base indistinctly streaked with whitish on a cinnamon ground; interior russet.

(*a*) Length 14, diam. 8, aperture 7.9 mm.; 5⅓ whorls.

(*b*) Length 15, diam. 9, aperture 7.9 mm.

Hawaii: North Kona at Honoula. Cotypes (*a*) in coll. A. N. S. P., (*b*) in coll. Bishop Mus.

The brown band, unaccompanied by a white one, is special to this form, which carries the area of the species well down the western side of the island, though not so far south as *P. p. errans* goes in the east. The types are old shells, worn at the summit, and containing young. In another lot the shells are dull, more or less corroded, and the color-pattern is almost obliterated. The largest measures 15.3 x 9.2 mm.

P. 122, 3rd line from bottom, for "Waimanalu" read Waimalu.

Unrecognized or undescribed Achatinellidæ, etc.

Helicteres sulphuratus Beck, Index Molluscorum, 1837, p. 51 "I. oc. pacif." Name only.

Helicteres leucozonalis Beck, t. c., p. 51, "I. oc. pacif." Name only.

Achatinella acicula, folliculus, unilamellata, lubricoides and *lubrica* of Schlüter, Kurzgefasstes syst. Verzeichniss meiner Conchyliensammlung, 1838, p. 8, are species of *Ferussacidæ*. Schlüter proposed *Achatinella* as a new genus for these European snails in ignorance of Swainson's previous use of the name.

Bulimus clausinus. " Shell dextral, ovate-conic, thick and solid, white, smooth, glossy, sometimes with an obscure, narrow, yellowish band revolving with the suture, and passing over the middle of the body-whorl. Whorls 5, convex. Aperture subovate; lip yellowish, thickened, coalescing with the body-whorl and forming an enamel on the left side of the aperture. Length about .7, diam. .4 inch. Hab. Hawaii" (*Mighels,* Proc. Boston Soc. of Nat. Hist., ii, 1845, p. 20).

Placed as "*L. clausiana* Migh." in *Leptachatina* by Hartman (Proc. A. N. S. Phila., 1888, p. 52). Unknown to Sykes and other authors. Possibly an Oahuan *Bulimella,* but it is

certainly undeterminable and should be dropped, since Mighels' types were destroyed by fire.

Achatinella ridua Pfr., Nomencl. Hel. Viv., 1878, p. 306, no. 31, error for *A. vidua.*

Achatinella tuba Gul., Pfr., Monogr., v, 167, error for *lutea* Gul., a MS. name which Pfeiffer printed in the synonymy of *A. tappaniana.* See Monographia viii, p. 217.

Achatinella turbinata Nuttall, Wahoo. Jay's Catalogue, edit. 3, p. 58, 1839. Nude name.

"*Spiraxis sandwichensis* Pfr. Shell subperforate, oblong-turrite, rather solid, waxy; spire turrited, rather obtuse; whorls 7½, a little flattened, plicate below the suture, the last a little more than one-third the length; columella compressed, twisted; aperture scarcely oblique, oval; peristome simple, the margins joined by a thin callus, the right margin somewhat dilated forwards, columellar margin somewhat reflected. Length 9, diam. 3 mm. Aperture 3 mm. long, 1½ wide. Cuming collection" (*Pfr.*, Proc. Zool. Soc. Lond., 1856, p. 335; Monographia, iv, 575).

Mr. Sykes (Fauna Hawaiiensis, p. 399) thinks this a form of *Bulimus lactifluus* Pfr., from Chili. If so, it must be a young shell. *Cf.* Manual, Vol. XIX, p. 13.

"*Bulimus kanaiensis* Pfr. Shell subperforate, conic-ovate, rather solid, striatulate and irregularly malleate-impressed, white; spire conic, sometimes gray above, the apex obtuse; whorls 5, convex, the last scarcely exceeding the spire, obliquely descending, rounded at the base; columella slightly arcuate; aperture oblique, truncate-oval; peristome simple; unexpanded, the columellar margin dilated, reflexed, somewhat appressed. Length 14, diam. 8 mm.; aperture 8 mm. long, 4⅔ wide. Mus. Cuming" (*Pfr.*, P. Zool. Soc., 1856, p. 332).

The name was corrected to *kauaiensis* in the Monographia Heliceorum, iv, p. 469. Mr. Sykes states that it is very close to *Bulimus albicans* Brod., of Chili, but he is "not quite sure of the identity, as the shell is slightly more succineiform" (Fauna Hawaiiensis, p. 399).

Achatinella faba Pfeiffer. "Shell imperforate, dextral,

ovate, rather solid, irregularly striate, glossy, white; spire convexly conic, the apex rather acute; suture simple; whorls 5, a little convex, the last a little longer than the spire, rounded; columellar fold above, strong, nodiform; aperture a little oblique, obauriform; peristome thickly labiate within, the right margin shortly expanded, columellar margin reflexed, adnate. Length 16, diam. 10½ mm. Sandwich Islands, Dr. Frick in Cuming coll." (*Pfr.*).

Achatinella faba Pfr., Proc. Zool. Soc. London, 1859, p. 30; Monographia, vi, p. 164. *Cf.* Sykes, Fauna Hawaiiensis, p. 307.

A lost species, which Mr. Sykes could not trace in the British Museum. By the small size, convexly conic spire and thick lip it seems referable to the *fuscobasis* series of *Bulimella,* though the proportion of length to diameter is more like typical *Achatinella* ("*Apex*"). It is smaller than any *Bulimella* except some of the *fuscobasis* group; the size being more like *A. curta* and its allies.

Like most of the Frick shells described by Pfeiffer, this was apparently based upon an exceptional individual. Many species have a white phase among other patterns. Such albinos are usually easy enough to classify because of their occurrence in colonies of colored shells; but a white shell, possibly of extreme or unusual shape, and without definite locality, may sometimes baffle the most sapient Achatinellist. When we have to deal with an unfigured form of which the type is lost, there seems no reasonable ground for keeping it out of the discard. It can never be positively identified.

Molluscorum Systema et Catalogus, Fr. Paetel, von Dr. L. W. Schaufuss, 1869, contains the following names, without references, and partly with a query in place of the authority. Besides these there are numerous errors in the spelling of other names, and wrong authorities are often given.

Achatinella agatha? Sandw. I., p. 83.
bensonia? Sandw. I., p. 83.
havaiana Rv., Sandw. I., p. 83.
magnifica? Sandw. I., p. 83.
scamnata Fér., Sandw. I., p. 84.

Achatinella subovata Fér., Sandw. I., p. 84.
torquata? Sandw. I., p. 84.
vulpina v. *sinistra* Fér., Sandw. I., p. 84.

Catalog der Conchylien-Sammlung von Fr. Paetel, 1873.

Achatinella cinnamomea Fricke, I. Sandw., p. 105.
cingulata Fricke, I. Sandw., p. 105.
compressa Pfr., I. Sandw., p. 105.
gravis Fér., I. Sandw., p. 105.
ignominiosus Pse., I. Sandw., p. 105.
impressa Pse., I. Sandw., p. 105.
octavula Pfr., I. Sandw., p. 106 (error for *obclavata*?).

The same, edition of 1883.

Achatinella agatha Rv., I. Sandw., p. 153.
anacardiensis [no locality], p. 153.
circulata Frick, I. Sandw., p. 154.
hawaiana Gulck., I. Hawai, p. 154.

The same, 4th edition, ii, 1889.

Achatinella semitecta Fricke, I. Sandw., p. 275.

Achatinella olesonii Baldwin. Cat. Shells Hawaiian Is., 1893, p. 5. Nuuanu, Oahu. No description.

APPENDIX II.

GENEALOGY AND MIGRATIONS OF THE ACHATINELLIDÆ IN THE HAWAIIAN ISLANDS.

BY

ALPHEUS HYATT.

[NOTE.—The manuscript of this paper was found in Professor Hyatt's desk after his death in 1902. In editing it, I have endeavored to alter the original as little as possible, and have been greatly assisted by Dr. C. Montague Cooke, of Honolulu, whose precise and extensive knowledge of these shells enabled him to perceive Professor Hyatt's meaning in instances where the author's statements were more or less ambiguous or incomplete.—A. G. MAYER, *Editor.*]

(*Jennie Arms Sheldon Fund Publication.*)

PART I: GENERAL STATEMENTS.

THE writer's attention was first attracted to this subject by Rev. J. T. Gulick and the acquisition of his first duplicate collection by the Boston Society of Natural History in 1889 afforded him the means of beginning studies that have been pursued more or less continuously since that date. The materials that have been used for study consist of this collection of 4154 specimens, 227 species and between 600 and 800 varieties as named by Mr. Gulick, and his personal collection consisting of 9,000 specimens. The Oleson collection of about 6,000 shells kindly lent by that gentleman, the C. M. Cooke, Jr., collection of about 7,000 collected with extreme care, and accompanied by a map showing the exact location of each lot of specimens, also generously lent to me. There is also a small collection presented by Dr. C. Montague Cooke, a small but valuable collection presented by Dr. Conrad Wesselhoeft, one from Mr. W. R. Castle, Jr., a small collection purchased from D. D. Baldwin containing some im-

portant species, the Boston Society's collection of about 4,000 shells and a collection of about 4,500 shells lent by Rev. Harcourt W. Peck. I have also had the benefit of studying the collections of the Smithsonian Institution and National Museum, Academy of Sciences of Philadelphia and the Museum of Comparative Zoology at Harvard, as well as temporary loans for examination, the collections of Cornell University. Rev. J. T. Gulick, Mr. D. D. Baldwin and Mr. C. M. Cooke, Jr., have also materially helped me by the benefit of their great knowledge of the species in the field. To Hon. W. DeW. Alexander, Rev. Oliver P. Emerson, Mr. A. B. Lyon, the U. S. Coast Survey and to others I am also indebted for material assistance in procuring maps and information necessary for my work.

The land shells peculiar to the Hawaiian Islands are of remarkable interest in connection with problems of evolution and heredity, since they are an extensive group wholly confined to these islands, and consisting of about 400 species. Many of these exhibit permanent varieties, and are represented by immense numbers of individuals. The field is practically occupied by these peculiar species to the exclusion of other more cosmopolitan groups of land shells which are represented by only about 111 species, and these are not so numerous in individuals.

The Hawaiian Islands are arranged in an almost linear arc of about 400 miles extending from Kauai and Niihau at the northwestern, to Hawaii at the extreme southeastern end. Their existence is due to volcanic elevations and eruptions.

The relative age of each island has been determined by geologists, and I find that the relative age, and evolutionary development of the faunas, is commensurate with the age of each island.

By pursuing the study of the faunas closely, I determined what appeared to be their natural course of evolution and apparent succession. A study of the phylogeny of the faunas appeared to demonstrate that Kauai, the northwesternmost of the chain, had the most primitive fauna, Oahu having the next in succession, while Molokai, Lanai and Maui although

more closely associated have faunas derived from each other in substantially similar succession, and by what seemed to be a very recent migration. These results led naturally to the conclusion that Kauai was the oldest, and that the others had risen above the waters in the succession indicated by the faunas. This was sound insofar as the age could be determined by the relative time at which each island had become covered sufficiently by vegetation to be suitable for the existence of the more primitive forms of land shells.

The fact that Kauai contained the oldest fauna of this group has already been stated by Baldwin and Gulick, and it has been generally admitted that each island had its distinct fauna, and also that each of the valleys, in Oahu especially, was apt to have some peculiar varieties or species.

Turning then to the geology, for more information, I found that Dana, Dutton, and others were in substantial agreement with my conclusions, basing their opinions upon the topography of the different islands and the comparative age of extinct and active volcanoes and lavas. This analysis was also carried into the separate parts of different islands. Thus I became convinced that so far as the migration of shells were concerned the western or Waianae range of Oahu was more recent than the eastern or Konahuanui range, and in Maui that the western mountain-peak of that island, Mt. Kukui, was older than the eastern region around the base of Mt. Haleakala. The last deduction has been confirmed by geologists, notably Dutton, but the first remains thus far undecided. So far as our present knowledge goes there is then in these islands the most remarkable case yet known of the evolution of a succession of closely connected homogenetic faunas which have evolved without serious interference from the invasion of foreign importations. The *Achatinellidæ* came to the island of Kauai, according to my deductions, obviously before other islands had become habitable; and they came in the shape of certain shells of very distinct primitive structure whose descendants are still found living in that field. Then all of the members of that family group were evolved from this island through the others in determinable

succession as clearly as if we could trace them from older to newer and still newer strata in the field of geology. The groups of genera so far determined in the family *Achatinellidæ* are as follows: [*Cyclamastra* P. & V.]; *Kauaia* Sykes; *Armiella* Hyatt, *Carelia* and *Amastra* Adams; *Laminella* Pfeiffer, *Perdicella* Pease. I have reduced these to the above list because in each case the group that appears as a synonym is not separable from that in which it is included, but is linked with some of its species by intermediate gradations, often by hybrids.

My definition of a genus in this family is a homogenetic group which has been practically (not theoretically) traced from variety to variety and species to species. I have on all important points found myself in close accord with the Rev. J. T. Gulick whose thorough studies of this group have placed in my hands the means of doing this work, and whose labors I hope some day to present with illustrations that will place him among the great pioneers in the history of evolution. A genus, in my opinion, is simply a genetic series which may conveniently be separated from other closely related series descended from the same common ancestors.

According to Major Dutton's account, (Report of U. S. Geol. Survey, 1882-83, Hawaiian Volcanoes), the Hawaiian Islands lie between 154° 30′ and 160° 30′ W of Greenwich, and 18° 40′ and 22° 15′ North latitude. They are therefore near the northern border of the great equatorial current which flows westward from the western coast of North America sometimes transporting materials from those shores to the islands. The length of the entire chain is from 350 to 400 statute miles and the distance from San Francisco about 2000 miles. There are eight islands and four barren rocks. Niihau, a small island, now without any testaceous inhabitants, lies at the northwest end of the series, and is followed by Kauai having only terrestrial land shells, and no arboreal species, in spite of the fact as stated by Baldwin that "Its extensive forests, luxuriant vegetation and moist climate render it peculiarly well adapted for the abode of *Achatinella*."

Kauai is nearly as large as Oahu, the metropolis of the *Achatinellidæ*, but has a much simpler topography. There is one peak of 5000 feet in the center of the island and the valleys radiate from this outwardly, whereas in Oahu there are two ranges, the longest of which, the eastern range, cuts across the track of the northeast trade winds, while the shorter or western range is nearly parallel with this. The highest peak in the former is to the northeast of Honolulu and is 3175 feet, while the highest peak in the western range is 4030 feet.

The four islands next to Oahu geographically and faunally, are a group by themselves, and can be treated as one except in the minuter study of the distribution of species. These are Molokai next to Oahu, Lanai and Maui, and the small island of Kahoolawe apparently having no shells of this family existing upon it.

The areas of these islands are as follows: Molokai, 190 square miles; Maui, 620 square miles; Lanai, 100 square miles, and Kahoolawe, 60 square miles,—in all 970 square miles.

Hawaii, the extreme southeastern island, is the largest and highest, and has the only active volcanoes in the chain. Its area is 3950 square miles. The recent and active volcanoes of Hawaii, the presence of extinct craters on other islands, the steady progress in size from northwest to southeast and the deeper valleys and more sharply set ridges and peaks of the northwestern islands, all tend to confirm the conclusions of geologists that the Hawaiian islands arose in succession through volcanic action, and by upheaval out of the water starting with either Niihau or Kauai; Hawaii being the youngest and largest of the group. Kauai is very nearly as large as Oahu, and Hawaii is much larger, and yet both of these extremes of the chain have meagre faunas compared with Oahu, and the other intermediate islands.

This shows that there is as yet no correspondence between the area or topography of each island and the abundance or scarcity of *Achatinellidæ*. Baldwin expressly states that Kauai is, apparently, extremely favorable for the develop-

ment of *Achatinellidæ*, and one would naturally expect to find here a larger and if possible, higher development of the family. But we are doomed to disappointment; the island yields no arboreal species; the shells are all terrestrial—Hawaii is also favorable, for, as Baldiwn states: "Its extensive forests are as well adapted for the support of Achatinella as those of any of the other islands." Nevertheless, it has a very small fauna.

Niihau, lying to the southwest of Kauai, has an area of 90 square miles, and the highest peak is only 1500 feet, and so far only one species of a sub-fossil shell has been found there, *Carelia sinclairi* Ancey, which is extinct at the present time. There are, however, certain correlations between the topography and the distribution of these shells, already noted by Baldwin (Hawaiian Almanac) which are of great interest, for he states: "That on a mountain chain with many culminating peaks the tendency is to a divergence of species; while on an individual mass of mountains concentrating towards a single peak, the tendency is to a convergence of species." He also observes in treating of Molokai: "It is about one-third of the size (area) of Oahu, and like it has a mountain range extending nearly thirty miles through its length. The range is furrowed on both sides with deep valleys. Some of these mountain gorges are very wide, and cut deep into the narrow axis of the island. The larger ones have proved an effectual barrier to the migrations of shells. The island is thus divided into three natural sections, and each section retains its own peculiar species without intermingling with those of the next section."

There is also a decided correlation between the relative ages of the different islands, assuming that Kauai is the oldest of those having living shells, and the kind of shells that are found upon them; and also it seems obvious that different genera came into existence in ascertainable succession upon different islands.

This succession appears to accord, in all cases so far as examined, with the genetic relations of these genera as determined by a method which the writer has used successfully

for many years, and happily succeeded in introducing to the favorable notice of the younger paleontologists of this country. This is founded upon what has been falsely called "the Law of Biogenesis" by Haeckel, and in spite of just opposition and well-founded criticism, adopted by a large number of scientific workers. This law was really discovered by von Baer, and completed by Louis Agassiz and Vogt and was simply baptized by Haeckel with an old name already having a fixed and a different meaning in scientific literature.*

Natural selection might be called upon to account for the brown protective colors of Amastras living on the ground, but the prevalence of brilliant, conspicuous colors in the arboreal species, and the presence of similar brilliant colors in some species that are habitually concealed, and the constant tendency to the repetition of similar variations in different species are all at variance with this hypothesis.

There are also other constant modifications of form that correlate with the general morphology of Gastropoda. The ontogenetic development of a gastropod follows certain general lines of modification. The protoconch is more or less bag-like, and when the conch is begun it necessarily starts as a tube continued from the aperture of the protoconch. In shells that revolve with the principal axis held continually in the same plane or nearly in the same plane, like *Planorbis,* two hollows, or nearly equal umbilici, are formed, one on either side of the shell. On the other hand, unequal or asymmetrical spirals are formed by excessive growth to one side which necessarily elevates the opposite side into the apex of a spire, and generally obliterates the umbilical cavity. Sometimes this remains for a time, but in most gastropods it may be said to be a lost character. Nevertheless in the most acutely spiral shells, as a rule, the earliest stages of the conch are less asymmetrical than the subsequent states.

In other words, the ontogeny shows that the primitive form

* Abiogenesis was originally used for spontaneous generation or life from inorganic matter and " biogenesis " for the theory that life was continuous and that organisms could originate or be generated only from life.

is equi-umbilicated. While the asymmetrical is a secondary modification occurring in more specialized organisms. In the ontogeny, also, of asymmetrical forms we find that the young are more loosely coiled than the adults. The umbilicus is frequently open in the *nepionic* and *neanic* stages when in later stages it is replaced by a columella or solid axis formed by the contact of the inner side of the whorl.

The *Achatinellidæ* are wholly asymmetrical, but the most primitive genus contains forms that are flat spirals having open umbilici on the lower side. This leads in Kauai itself into a series of more closely coiled and more asymmetrical spires having solid columellæ in adults; and these into others, of the genus *Carelia*, having elongated acute spires that can be compared with those of highly modified shells like *Turritella*.

Primitive Amastras, closely affiliated with the primitive forms above described, that are not unlike a common Helix in aspect, show traces of their derivation in their low spires and so-called perforated columella. This perforated columella is in reality an umbilicus reduced to the dimensions of a tube; and even on Kauai this perforation disappears in adults of one or two species. The fossil Amastras of Oahu are apt to have perforated columellæ; and on all of the islands the most primitive forms exhibit more or less of this character. In each series there are species and varieties that can be distinguished by their more complete asymmetry. This is shown in their more solid and twisted columella, and in their more slender and elongated spires. There is one entire series in Oahu which has all of the species of this type, and one of them bears the appropriate name of *Amastra turritella*.

Turritelloidal shells appear repeatedly both less markedly as variations and more decidedly as species on all of the islands.

All of these have a highly acute elongated spire quite different from that which is commonly seen in Amastras that live exclusively on the ground, and on this account they have been placed by Hartman in the genus *Laminella*. *Laminella*

proper is a highly colored group of arboreal shells, in which we may include *Perdicella* which is also very nearly connected with *Amastra*, through species like *Laminella gravida* of Oahu that have spires of dark brown similar to those of some shells of *Amastra rubens, cylindrica,* etc., that have a coarse, friable periostracum and elongated spires showing a decided tendency to evolve turritelloidal forms. The basal volutions are more globose and the apex more acute in *gravida*, but this species is an intermediate form in other respects leading not from the semi-arboreal turritelloidal Amastras into *Laminella,* but from the turritelloidal ground shells into this genus or group, which includes the very distinct and highly colored *Lam. sanguinea* and other forms with turritelloidal spires that are found mostly in semi-arboreal habitats on low bushes, ferns, etc., according to Cooke and Gulick.

The apex in the nepionic stage is smooth in *Laminella* and of the same dark horny aspect as it is in most of the species of *Amastra* on Oahu, and the columella is highly developed, twisted and perforated, as it is in *Am. turritella* and its allies.

In the genus *Amastra* the shell is usually dark brown. The species live on the ground and are present in all the islands of the Hawaiian group that are inhabited by land shells. The species, as in all other genera, are so closely connected that it is very difficult to separate them. They have a single spiral fold on the lower edge of the columella. This fold is not characteristic of the genus but is shared in common with all the other genera of the family *Achatinellidæ*, occurring only in these islands. Nevertheless there are two marked deviations from this homogenetic characteristic, for in many individuals among a limited number of species, all of the genus *Amastra,* there is a slight tendency to form a second fold above this, but it does not take the definite form of a tooth-fold except in some very rare examples, and it is in these an obviously sporadic development having no genetic significance.

In about fifty thousand shells of this family this occurs

in very few examples, all belonging to the genus *Amastra*. One single example has been found in which the columella had three definite tooth-folds, evidently an isolated, sporadic variation. This last case appears never to have become genetic in any series of forms so that one could call these a distinct group or species. The case of the two or double tooth-fold does not, however, appear in this way, but only on the island of Lanai and in the one group of *Amastra biplicata* Newc. It occurs, however, in so many shells and in such definite and invariable succession that they are universally recognized as one species, *Amastra biplicata*. This has long been known, but the remarkable interest and significance of this fact has not been noted. It is one species in the genus Amastra, or if another view be preferred, a new genus in the family of *Achatinellidæ* departing in a new direction so widely that it must be cited as an exception to diagnostic, analytical description of that family.* Another exception occurs in two species on one island, but in this case the deviation consists in the absence of the single spiral tooth-folds so universal otherwise in this family group. The variation in this case is also heralded by an anticipatory mutation which occurs in individuals of other species occurring on other islands.

Another matter of interest in this connection is that the shells showing mutations of the double tooth-folds, and the absence of folds have no obvious or traceable connection with the species characterizable by the possession of similar and permanent variations. They appear to be of independent origin in different genetic series occurring on different islands. Thus while homogenetic in their own series in their own locality, they are simply homoplastic repetitions of common tendencies when compared with the mutations occurring in other genetic series in other islands.

This indicates the possible beginnings in each case of entirely distinct genetic groups that might under favorable

* Several species of *Amastra* and *Laminella* have a second columellar fold.—H. A. P.

conditions be perpetuated as well marked genera or family groups. It is obvious, also, that the isolated case of the columella with three folds indicates another variation having genetic possibilities. These have all, so far, been arrested in their evolution, and we can speak of them with reference to the phylogeny precisely as we describe the arrested development of parts and characteristics in the life history or ontogeny of the individual.

The color patterns have a similar history in this group. The individual mutations range from a normal uniform brown to a very light brownish-white, or in the opposite extreme towards black, and the patterns under certain conditions may show localized zigzag bars or straight transverse bars, or revolving bands. All of these have a fuller expression as permanent characteristics in some species, but shells displaying the mutation of revolving bands are almost as rare as those showing the double tooth described above; and there are only about three species of Amastra that can be characterized as banded.

On the other hand, there is no comparison between the tooth-folds and color patterns in other genera of this family. In the arboreal forms, genus *Achatinella* proper, the colors often vary in the same species from colorless shells, true albinos, through intermediate grades of browns and greens, often brilliantly banded. to dark uniform patterns often brown or almost black.

There is in most species a constantly reiterated tendency to swing between these two extremes, one being the absence of all color and the other a very dark uniform pattern, while the more normal shells may display brilliant color patterns often taking the form of alternating bands. Here and there one or the other of these mutations become genetic, and they are apt to become more or less permanent and predominant in some species; but in no case is any special pattern so general as to exclude mutations more or less parallel with those of other species. This is obviously variability taking place without the interference of natural selection or apparently any selective laws depending upon the advantage

of any particular pattern to the species. There are no known enemies which could be attracted by the colors of these shells nor do they seek protection from any so far as known. The only possible cause of limitation has been suggested by Mr. Gulick. He thinks that the colors of each species are made up by the crossing of a limited number of varieties which migrated across the ridges and mingling in new localities of neighboring valleys necessarily produced a distinct combination of patterns and colors from those of the parent species.

This may or may not account for the differences observed between closely related species that occur in contiguous valleys which are separated by high ridges, but the fact that there is parallelism in the color patterns in different species occurring in different valleys, is easily observed. This parallelism is also obviously divisible into homoplastic similarities and genetic differences as shown in the predominance of some definite pattern or color in the same species accompanied usually by differences in proportion, size and often direction of the spire.

The tooth-fold is also more constant in arboreal forms, and no case of absence or of the presence of additional folds has been observed. This greater permanency in the generic and family characters is obviously similar to what Williams has observed, and which he considers as a secondary condition acquired through inheritance — whereas, the variable ones noticed in the tooth-fold and columella of *Amastra* would be explained as due to the greater force of inherent variability in this more primitive genus.

This is true, as we have said, of all such primitive forms, and still more remarkable examples of this law of accelerated divergence are present, in these islands, in genera that are more primitive than *Amastra*, but there is this significant qualification: They occur in one island, Kauai, which is the most ancient of the group; they are survivals of a still more ancient and variable fauna composed wholly of ground shells which are divisible into several distinct genera. They occupied a perfectly free field and evolved several large robust

types of shells; but these all died out. Whereas, the small insignificant *Amastra* and another still smaller genus of ground shells, *Leptachatina,* that arose in the same fauna, or migrated from island to island, persistently held their own.

Leptachatina is a glassy shell, smaller than *Amastra,* and adapted for both living on the ground and very rarely on plants in places unfavorable for the existence of other genera of this family, such as in open country, and is now found on all of the islands. This genus is also most abundant in a fossil state, and is comparatively invariable. It maintains its characteristics without any marked changes in all locations. Its characteristics are those of a specialized type and there is no indication in its structure that it is the ancestor of any other genus. On the other hand, there is strong evidence that it is a modified descendant of the Kauaiian species, *Amastra nucleola* Gould. We can therefore neglect this series as having no further meaning in the phylogeny.

In Oahu, the island next in geologic age and geographic succession to the southeast, the only shells of this ground-living group found as fossils are *Amastra* and *Leptachatina,* the genera first evolved on Kauai. On this island the migrations extended in two directions; first geographically along the surface of the ground. Here they met with more varied conditions than in Kauai but their habitat as long as they occupied the surface alone was practically similar to that of their ancestors on Kauai. They therefore remained the same dark-colored ground-living shells, but evolved a number of connected species to fill this field.

The trees were, however, open to them, and when they ascended them we find that different series and genera arose marking distinct concordant stages of evolution.

The genus *Amastra* as limited and defined by Gulick has several series of forms on Oahu. I divided these from each other by following the genetic lines that connected one species with another through their similarities and intermediate gradations and this was done without reference to any other class of facts. Among these series of *Amastra,* or *Amastra*-like forms, one was remarkably distinct in the possession

of an acute, elongated spire differing from all the others except in so far as a few species were concerned. Subsequently, upon looking into the literature, I found that Hartman had referred these to *Laminella* and not to *Amastra*; while Gulick and others, including myself, had not been able to separate them from *Amastra*. Still later and upon consultation with J. T. Gulick, Dr. C. M. Cooke, Jr., and other collectors, I found that these same species were collected upon low bushes, trees and ferns, and might be properly termed semi-arboreal. They are as follows: *Amastra turritella* Fer., *nigrolabris* Smith, *rudis* Pfr., *spirizona* Fér., *grossa* Pfr., *intermedia* Newc., *variegata* Pfr., and *frosti* Ancey. Smith reports in his original description of *Am. nigrolabris*, that this species is procured both on the ground and in trees.

There is also another group of Amastras that evolve into highly turritelloidal shells, but some of these are found solely as stated by Cooke upon the ground such as *Amastra tristis*, a shell with peculiarly blunt apex and *Am. seminigra* Hyatt; *Am. rubens* Gould; and *Am. corneiformis* Hyatt, the last of these being quite as elongated and acute as *Am. grossa* and others in the *Am. turritella* series

This series though *Amastra rubens* and *cylindrica* are apparently the ancestors of a group having quite distinct and more highly turritelloidal spires, and living on low bushes, trees and ferns, according to Gulick and Cooke; and are classified by Gulick, Hartman and others with the genus *Laminella*. This series contains *Am. gravida* Fér., *sanguinea* Newc., *tetrao* Newc., *picta* Migh., *bulbosa* Gul., *straminea* Rve., *venusta* Migh., *depicta* Bald., *helvina* Bald., *citrina* Migh., *remyi* Newc., *concinna* Newc., and *alexandri* Newc.

The five first named have the peculiar periostracum of *Amastra*, more or less covering the shell. *Am. sanguinea* is blood red in color, and *Am. depicta* is sometimes highly colored.

All of these Amastras have the dark, horn-colored, smooth young shells that occur in the primitive forms of *Achatinellidæ* on Kauai, and in nearly all of the Amastras on the island of Oahu, and while none of them exhibit a double

tooth, there is a decided tendency towards the evolution of an additional spiral fold on the columella.

The topography of Oahu changes as one proceeds northwards. The highest peak in the eastern range is Mt. Konahuanui, 3105 feet, situated about 15 miles from the southernmost point of the island. From this peak to the northern end of the island there is a gradual lowering of the heights until beyond Waikane valley, the crest is only about 2360 feet high and the intermediate valleys are separated by wooded spurs that do not oppose any serious obstacles to the migrations of the species. It is obvious that this relatively flat, low-lying region must have quite different conditions from the much more broken southern part near Honolulu.

The crest of the eastern range shuts off from the interior, the trade winds that blow strongly from the northeast for nine months in the year. The crest therefore gives much greater shelter to the inner or western sides of the hills. These winds also beat upon the unsheltered eastern side of the Konahuanui range and here the difference on this account alone is apparent in the difference in the vegetation of the two sides; the eastern sides being scantily and the western thickly covered with trees.

The Bulimellas of Oahu thrive high up on the ranges and extend to the outer, wind-beaten, eastern or coast side of the eastern range of the island between Waiahole and Hauula valleys. The Achatinellas, on the other hand, affect more sheltered locations, are unfavorably affected by this wind-beaten side and the species become smaller and individuals less numerous as one proceeds northward along the eastern side of Oahu toward the northern parts of the island. Achatinella was not very successful in crossing the middle parts of the island to the western range, and not a single Bulimella succeeded in crossing the central plain of the island.

Apex, however, thrives in locations between *Achatinella* and *Bulimella*, and while it was less successful than *Achatinella* in crossing the crest of the Konahuanui range to the coast side, it was on the other hand, the group best suited to

cross the central plain of the island and occupy the western, or Waianae range where it is by far the most abundant shell.*

Bulimella has a rougher shell and more uniform coloration in the southern parts of the range, but changes as it proceeds northwards and especially on crossing the crest in the northern part of the range. The species evolved in this region are more numerous, larger, the shells smoother and more brilliant in color and more elaborate in their patterns.

Achatinella throws, or rather did in Gulick's time (1853-54) out a colony of species that crossed the crest to the coast side, and the changes that occurred in this colony were very significant. They consisted of comparatively small, bright-colored, banded species which resemble those that occur to the north and on the same side of the mountain range, but are widely separated from them by a barren region having no shells of any kind. The main body of Achatinellas marched northward on the inner watershed of the eastern range of Oahu, here and there evolving large, brilliant shells until they reached the northern region of the island. There the shells are smaller, and although still striped, are sensibly distinct from their southern progenitors. These small shells sent migrants across the range to the coast side, the same species sometimes occurring on both sides of the range. The number of species of *Achatinella* in this region also sensibly diminished, where as in *Bulimella* the number of species increased.

The small northern species are so distinct that although closely connected by gradations with the southern forms, a limited number of them have been set apart by several authors as a distinct genus named *Eburnella* by Pease I have, however, not been able to separate any of them from their southern affines. Some authors have also thought that certain of these small shells belonged to a genus *Partulina* that

* In 1898 Professor Hyatt published a short paper in "Science", volume 8, p. 395, in which he concludes that the genera *Bulimella, Achatinella,* and *Apex* of Oahu originated from a common ancestor, the *Achatinella phœozona* of Kuliouou valley near the southern end of the Konahuanui range of mountains.

occurs on other islands but has so far as I know no representative on Oahu. They are, however, directly connected, and barely separated as distinct species from other accompanying species that are placed by the same authors in the genus *Achatinella*. They have identical young, the slender, highly-polished, smooth shells and the colors of *Achatinella*; and no trace of the zigzag and marbled patterns and peculiar colors common in *Partulina*.

In general, it may be stated that the arboreal stations in the Hawaiian Islands were occupied by highly colored shells in which the coarse friable brown periostracum of the ground shells is absent and the color patterns were highly complex.

The differences evolved in these distinct genera are thus correlated with their different stations and distribution, and they certainly appear to have arisen in connection with their change of environment.

It seems obvious also that these could not have been evolved had not the new fields and stations been open and unoccupied. If we assume that the observed differences were acquired in consequence of the migrations of the ancestral forms of each group or species into new situations, the whole complex association becomes apparently explicable.

It is also obvious in these islands that the variations are not only coincident with migration into new fields and stations, but they are also limited to these geographically, and species are not as a rule maintained in their original form when new migrations take place.

Species are, however, traceable by hybrids or by gradations into others along lines of unbroken continuity throughout the eastern chain of Oahu in *Bulimella*, *Achatinella*, and *Apex* wherein they can be followed along the same lines of migration to their termination in the western range. Finally, the same may be done in all the groups that range from island to island, the connections of course being less perfect than in forms living upon one and the same island. The species, however, can be followed by groups and sometimes by graded variations so slight that particular forms can be pointed out as the migrants that must have come from one

island to another. In other words genetic lines of descent can be traced in the shells throughout the islands beginning with Kauai, the oldest geologically, and following the whole chain to the southeast until one arrives at the most recent island of the archipelago, Hawaii.

This entire picture of variability appears therefore like those that have taken place in past geologic times, and known to occur when an animal type of primitive form finds itself in a free field, either an uninhabited locality as Kauai must have been when the first ground shells reached there, or a new and unoccupied station, as the bushes and trees of Oahu were, when the ground-shells or their modified descendants began to creep up on their stems.

The opportunities for expansion by the evolution of varied types were certainly afforded by the surroundings, and it must be acknowledged that this divergence into new groups takes place along the open ways of migration. This is difficult to account for by any hypothesis that does not consider the primitive Amastras as a plastic type the structure of which was capable of being modified so as to occupy all the available environments afforded by these islands. If this be so, the various successful types evolved in distinct genera certainly appear to have arisen as secondary modifications, which could not have come into existence if the new fields and stations had been already occupied or were inaccessible. The variations are, as a rule, obviously still coincident with and limited to the locations and islands in which they originated, and this correlation cannot be accounted for unless we grant a causal relation between the surroundings and their faunas.

Part II: Remarks upon Relationships between Genera.

[The more or less disconnected notes constituting the second part of this paper must be of interest to students of the *Achatinellidæ*. When death overcame him, Professor Hyatt had all but completed his preparations to visit the Hawaiian Islands, the funds for such an expedition having been provided by Mrs. Jennie Arms Sheldon. In certain cases, doubtless, his ideas of the actual relationships between genera would have been somewhat modified and all would have been amplified and rendered more precise through a study of the animals in the field.

These notes are, therefore, preliminary statements written by Professor Hyatt, and which he expected would be modified by the studies he hoped to perfect while in the Hawaiian Islands.—A. G. M.]

Remarks upon Partulina.

Sub-series of Partulina semicarinata: The first of the two species in this sub-series, *Partulina semicarinata* of Lanai, has a uniform light-colored pattern throughout life with lighter colored young. The young and adult stage has a prominent, well-formed ridge or keel that disappears only when near the old aperture.

In *Partulina hayseldeni*, also of Lanai, there is a finely colored young like that of *P. virgulata*, having broad white shoulder band and darker side to the volutions. This pattern is common on the full-grown adults of some varieties of *Achatinella polita* of Molokai and is found in the young of varieties of *mighelsiana*. The ridge is prominent in the shell but disappears earlier in the last volution. The tendency of *P. virgulata* to have young with angulated sides until a late stage, and the presence of albinos in which the apex has almost completely lost its colors, shows that this species belongs with *hayseldeni* and not with *variabilis* or any more slender form.

Partulina semicarinata is a dextral species which stands alone. The apex is acute and the spiral similar to that of typical shells and the general form, aperture, columella and tooth also like typical *Partulina*, but the shell surface is as smooth as in any Achatinellas; the spire increases more evenly and rapidly, making a stouter shell, and there is a decided keel on the basal volution until a late stage of growth when it suddenly and completely disappears. This keel has not the sub-angularity so often noticed in the young of various species but is a distinct prominent ridge. Both form and ridge are like those of *Kauaia* until a late age, then the latter disappears, the general aspect, the presence of striation in the young that occurs only on the mature volutions of *Kauaia* and columella, tooth and aperture are like typical *Partulina*.

Part. hayseldeni Bald., is a shell having an apex like *virgulata*, but becoming uniform light chestnut brown in later stages and having bulimelloid aperture and columella. One shell in Cooke's collection (No. 2204) has two keels until a late age and another does not lose the keel entirely even in extreme age. The shells of the sub-series *virgulata* are uniform and banded, but the young in nepionic stages are invariably banded with white on the shoulders and have brown sides.

Partulina mighelsiana Pfr., constitutes a group of itself, which we may call the *mighelsiana* series. The apex of *Partulina mighelsiana* Pfr., has the colors of *Achatinella* and *Bulimella*, but the form is more slender and more acute, and like that of typical *Partulina*. There are no signs of zigzag or marbled patterns, but instead the banded patterns prevail as in *Achatinella*. In one species, *Part. mighelsiana* of Molokai, the aperture and columella are constantly similar to those of the Achatinella-like shells of the *bella* series, and in *subpolita* of Molokai the form and characters and apex are precisely intermediate between *mighelsiana* and *polita*. I have examined altogether 53 specimens of *Partulina mighelsiana*, including several varieties, without finding in the young any trace of the barred or marbled pattern common in degenerate forms of *Partulina*.

In Cooke's collection there is a fine series of varieties of *mighelsiana* that exhibit intermediate forms between this and *Achatinella polita* in full-grown shells. In this, and especially in Gulick's collection, the only characters that separate the young of some specimens are the somewhat lighter color of the dark sides of the apex and the brown band on the base; there is one shell in Gulick's collection in which this last is the only difference, the apex having white shoulder band and dark side precisely as in nepionic stage of *A. polita*.

In quite a number of Cooke's shells the white shoulder is present in the young and the side of the volution underneath is darker, and it is obvious in these characters and in the smooth, highly polished shell, that the affinities with *polita* are very close and indicate a common origin for both species.

In *A. polita* in the Cooke collection (No. 2014), one shell has the band on the base and looks decidedly like a transition or a hybrid between *polita* and *mighelsiana*. This has also the white young of *mighelsiana* with the nepionic colors of *polita* and has the dark inner rim to the aperture so often found in *mighelsiana*. Cooke has placed it with *polita*, and in this I agree with him.

Partulina variabilis Series: These are Bulimelline forms with the narrow acute flat-sided spire of Partulina. In *variabilis* of Lanai, the callus or shield is present only in the largest shells and very often absent at all stages. This is transitional in others in which the aperture is constantly bulimelloidal. It is apparently an offshoot of *P. mighelsiana* and so far as I can see does not connect with any other species although coming very close to some in its general aspect. The species are as follows: *Partulina variabilis* Newc., *P. lactea* Gul. of Lanai, and *Part. nivea* Bald., *dolei* Bald., and *eburnea* Gul. of East Maui.

Relationship between Partulina and Achatinella: The conclusion seems unavoidable that all true Partulinæ exhibit in their young stages direct affinity with *Achatinella*, and that the genus was derived from *Achatinella* that migrated to Molokai and probably began its existence on that island, for I have traced direct transitions from *Achatinella polita* to adults of *A. polita* in Cooke's collection and the young in *Partulina mighelsiana* in Molokai. These were found in other collections showed very close affinities.

Three species of *Achatinella, A. bella* Rve., *polita* Newc., and *subpolita*, occur outside of Oahu on the island of Molokai. These four species cannot be distinguished from Achatinellæ of Oahu by any character so far as I could ascertain, for the columella is very similar to that seen in many species on Oahu.

In East Maui there are three species of Achatinella, *A. anceyana* Bald., *nattii* Bald. et Hart., and *porcellana* Newc. In all three of these species there is the same tendency observable in varieties to imitate the aperture of *Partulina* while others retain the thinner apertures and columellæ of true

Achatinella. All of them have the surfaces, apices, and general aspect of true Achatinellas.

In these forms, therefore, outside of Molokai, there is a constantly recurring tendency to imitate the thickened columella and apertures of *Partulina,* but this does not extend to any alteration of the general aspect nor of the texture of the surface as has been stated above, nor in the patterns and colors, the colors being brilliant and banded throughout the islands.

The characters of the apertures have caused most authors to include either all or part of these in the genus *Partulina,* but the colors and forms are, it appears to me, conclusive in favor of the theory of direct connection with the unquestionable Achatinellas of Molokai, and if this be true, it follows necessarily that the *Bulimella* apertures are simply parallelisms with *Partulina* and have consequently neither genetic nor taxonomic significance except within the limits of the series itself.

Achatinella nattii Bald. and Hart. has the typical apex and general aspect of *Achatinella* in most specimens, but there is a tendency in many shells to form a callous or shield which often develops to be as large and well marked as in *Partulina.* The same is true of the outer lip, that often becomes thickened at the same time. So far as these characters are concerned, this species or some of its varieties is a *Partulina,* but all of the specimens have the apex and external surface like *Achatinella.* All of these have either a uniform or banded pattern in the young, never a cross-barred or zigzag pattern.

Partulinella marmorata series: This group consists of shells having an apex similar to that of Achatinella in shape but with heavier longitudinal ridges which also persist throughout the later stages of the shell. The surfaces in later stages are also apt to have persistent transverse ridges of growth much coarser than in Achatinella and like the latter in that the longitudinal ridges also persist and usually cross them even on the last volution. The roughness of the shells is therefore a marked characteristic just as it is in the *Partulina virgulata* series.

The apertures vary from toothless to those with prominent tooth-folds, but the shield on the columella and the structure of the peristome occurs in almost all of these forms. A marked characteristic is also the presence of bars or zigzag lines of color in the early neanic stage or throughout life in all the shells, as a rule except in extreme cases of albinism.

The shells of the *Partulinella marmorata* series have a peculiarly brown barred pattern either throughout life or in the early neanic sub-stage. There are two sub-series; the first consisting of highly colored shells with elaborate marbled or banded patterns that show affinity with *Partulinella dubia* in these colors and in their young; but as a rule these have large columellar tooth-folds. The second sub-series consists of shells that have lost these more highly colored patterns in their later stages in different degrees and have remnants of these only on their young and finally only in some individuals in the most degenerate species.

The sub-series of *P. marmorata*, shells with marbled or banded pattern, is as follows: *Partulinella proxima* Pse., *redfieldi* Newc., *tessellata* Newc., *rufa* Newc., from Molokai; *Partulinella crassa* Newc., *P. perdix* Rve., *pyramidalis* Gul., *splendida* Newc., and several others from West Maui; *Partulinella marmorata* Gould, *plumbea* Gul., *grisea* Newc. from East Maui *P. tessellata* and *rufa* have either no tooth-fold or a very slight one, and this condition is also found in *P. crassa.**

Marmorata series, Sub-series of P. horneri: These consists of the species heretofore included in *Partulina* that occur on Hawaii. They resemble the toothless forms of Oahu, Molokai, and Lanai, and are especially similar to *P. crassa* of Lanai. The spire, however, is more concave and more acute and increases more rapidly and more regularly, and the last volution flares out with a more even and regular form. The columella may be open or closed, but is always toothless and has

* *Partulinella* is a new subdivision of *Partulina* proposed by Professor Hyatt for species with the last embryonic whorl marked with protractive stripes; the shell otherwise like *Partulina s. str.* *P. marmorata* may be taken for type.—H. A. P.

a distinct shield or callus. The peristome is apt to be expanded but is not always thickened. The young have the patterns of the young of the *P. tappaniana* series except in degenerative or albino forms. The species are *P. hawaiiensis* and *horneri* Bald., and *physa* Newc.

The eastern variety of *hawaiiensis* has such lively colors and coarse barred pattern that it suggests that this series may have arisen from migrants like the existing forms *P. zebrina* and *zebra* of East Maui.

The relationship between Partulinella dubia and the Marmorata group: The only clue that I at present possess with regard to the origin of this group consists in the primitive colors and characters of *Partulinella dubia* Newc. which is found on Oahu. For a long time I regarded the species as a migrant from some island to the eastward of its home that had found its way there and become somewhat retrogressive in colors and columella. This view can still be maintained, but it seems more likely that *Partulinella dubia* is a remnant of some primitive form. I was led to this conclusion by finding in the Boston Society's collection a fossil Amastra, unfortunately without a label, which possessed decided resemblances to *Partulinella dubia* in its toothless columella and general form. Its spire was, of course, Amastran and distinct, and the columella had a comparatively large perforation. It was similar to *Am. antiqua* Bald. in aspect, except that the tooth was wanting. Fortunately Newcomb observed in very old shells of *dubia* a tooth was present and this enables us to make the connection with the *Marmorata* series more confidently. The transitional character of the habitat "on bushes" is also notable.

The colors of *dubia* are distinct from any that occur in *Amastra*, but the reticulated pattern and zigzag lines that occur over the entire spire of *Partulinella dubia* is a primitive character and in some varieties there are large bars that approximate to those of *marmorata* and *perdix*.

I have therefore provisionally supposed that *dubia* represents more nearly an ancestral stock of *Partulinella* than any other species, and that the migrations of this series started

from Oahu, as the first locality in which the group originated. *Partulinella dubia* of Oahu is probably a remnant of an ancient series which probably sprang from large Amastras having no tooth-folds and also possessing the zigzag or barred reticulated pattern not very widely different from that of *Am. transversalis*.

The Sub-series of Partulinella tappaniana: These are shells with white or light backgrounds and slightly banded patterns resembling *mighelsiana* and those of the *variabilis* series that are albinos, but in these every species has throughout, or in some individuals, a pattern barred or marbled with brown in the young.

Partulinella dwightii of Molokai and *lignaria* of West Maui belong to both sub-series. The former connects with *P. crassa* of Lanai. Some of its varieties are marbled throughout life, and some are white except for the zigzag bars in the earliest neanic sub-stage.

Some of the shells of *Partulinella proxima* of Molokai are very close to this series as are also *P. tappaniana* Ad., *attenuata* Pfr., *terebra* Newc., *ampulla* Gul. of West Maui, and *P. eburnea* Gul., *P. dolei* Bald., and *P. nivea* Bald., of East Maui. The difficulty in distinguishing highly retrogressive shells of this sub-series from those of the *variabilis* series is perhaps at present insuperable. Some of the *P. tappaniana* series such as *dolei* and *eburnea* may belong to this sub-series. That is to say, their completely albinized young may have originated in the same way as the completely albinized young of most shells in *P. tappaniana* Ad., for example, through the non-appearance of the barred pattern in the individual.

Relationship between Perdicella and Partulinella: Sykes, Fauna Hawaiensis, p. 329, has selected *A. helena* Newc., as the type of *Perdicella* Pease, and I propose to follow him.

Perdicella helena of Molokai is one of the stoutest of the dwarf forms composing this group. Its colors and patterns, basal band and toothless columella, barred young, and finely wrinkled surface due to the crossing of the transverse ridges of growth by longitudinal ridges, show that it is a dwarfed form derived from some species of the *Partulinella marmorata*

series; and its nearest affines now living are *Partulinella dwighti* of Molokai and *P. crassa* of Lanai. The more elongated species of this series are *Perd. theodorei* Bald. of Molokai. This makes genetic connection with *P. ornata* Newc., of West Maui and *P. mauiensis* Newc., of Maui. These species have no tooth-fold or only very slight spiral ridges on the columella and in the last three the forms are much elongated and more turritelloidal than in *P. helena*. The parallelism with *Carelia* is very marked in form as well as in the toothless columella.

The highly specialized habitat of *helena* is stated by Newcomb to be within the coil of the *Ti* (Dracæna) leaf at the point where it starts from the stem, is exceedingly suggestive when taken in connection with the dwarfed aspect of this species and others of the same genus supposed to have originated from some such ancestor as *P. proxima*. [*P. helena* ordinarily lives on leaves and twigs of numerous shrubs and trees. H. A. P.]

Relationship between Newcombia and Perdicella: The genus *Newcombia* was described by Pfeiffer and the first species mentioned under this name is *Achat. helena* Newc., from Molokai. Pease placed this species, and the two following in other genera, and used the fourth species, *Newcombia cumingi* Newc., as the type. If the author and Mr. Baldwin are correct in their translation of the facts, this action of Mr. Pease appears justified if the name can be maintained for the extremely elongated, rough, sinistral shells having an umbilical perforation and no specialized tooth-fold, but having a callous deposit or swelling at the base of the columella. These three characters are always found in *Newcombia cumingi* Newc. of West and East Maui and *Newcombia newcombiana* Pfr., and *plicata* Mighels, *cinnamonea, sulcata* Pfr., and *canaliculata* Baldwin, all of which are from Molokai, the metropolis of the genus. The genus is certainly limited to Molokai and Maui. Its absence on the adjacent island of Lanai is very remarkable and interesting but entirely in character with its highly specialized form and unique ornamentation.

The connection between *Newcombia* and *Perdicella* is shown through the resemblances in color and form of the young of *Newcombia* to those of *Perdicella*. They are as a rule more slender than the most primitive species of that genus, viz. *P. helena*, but are quite similar to the more modified and more slender forms of *Newcombia* itself, like *N. perkinsii* Sykes of Molokai.

The resemblances are better seen in the young of *Newc. cinnamonea* and some of the smoother species than in the more highly modified shells like *sulcata*, etc. This evidence is strongly in favor of the direct derivation of *Newcombia* from some form like the *Perdicella helena* of Molokai.

The Relationship between Amastra, Kauaia, [Cyclamastra], Carelia and Armiella: Amastra, Kauaia, [Cyclamastra] Carelia and *Armiella* in Oahu and Kauai have smooth shells in the earliest stages and there is a common form in the nepionic stage. This has somewhat stout and rapidly increasing volutions, the surface is covered with fine transverse ridges or growth-bands. The bases are separated from the plano-convex dorsal sides by a more or less prominent subangulation, but this is never developed into a keel nor are there any coarse, transverse costæ on the dorsum. There are also no longitudinal markings of any sort. Keels, when present, and longitudinal ridges are introduced in late stages in [*Cyclamastra*], *Kauaia, Armiella*, and *Carelia*.

In *Armiella* the columella is only known in large shells and in them it is solid.

In *Carelia* the columella is known in the young of *C. dolei* wherein it remains solid or incomplete until a comparatively late stage and is solid also in the ephebic stage, but in one shell there was a small perforation when the shell was about one centimeter in length and was then just closing, for it was entirely closed in the same shell when four millemeters longer. In some others it was present but very minute at an earlier stage, and in some it seemed to be absent altogether at every stage. It was present in two shells of *C. adusta* when the shells were about six mm. in length (vertical diameter) and closed at one centimeter. Its beginning was not traced in these two shells.

In *C. bicolor* there is a very minute perforation in the neanic stage and there are indications in another individual shell of the presence of a somewhat larger perforation. The columella in [*Cyclamastra*] is at first incomplete in the young then becomes complete and remains complete, the umbilicus being open throughout life.

In *Kauaia* the history is similar to that of *Carelia* in the young, but the columella has a long straight ventral or inner deposit, and during the period or stage of the completed columella the umbilical opening is small and similar to that of the *Amastra rugulosa* group of Kauai. In a more advanced age such as the ephebic and gerontic stages, the columella again becomes solid, the umbilical opening closes, and the deposits are less, and are plastered directly against the axis.

The Amastræ of Kauai have a columella which is long and straight in shells that retain an open umbilicus; and the aperture in such examples is similar to that of [*Cyclamastra*] which never closes its umbilicus, and to the young of *Kauaia* during the stage when the umbilicus is open. In shells that close up the umbilicus, a variation that occurs apparently in species having an open umbilicus, the columella and aperture resemble that of *Kauaia* in its older stage and after its umbilicus closes.

In all these species the thick brown periostracum is a marked characteristic, and a tendency to put on more lively colors is only shown in a few species by bands, etc. [*Cyclamastra*] is obviously the nearest to the ancestral form of *Amastra*. This has an open umbilicus, and form both of spire and aperture and columella which is more or less repeated in the young of all other species in the neanic stage.

The gradation appears to be as follows: [*Cyclamastra*] is directly connected with *Kauaia*. *Kauaia* is similar to it only in the young. *Armiella* is similar to *Kauaia* and descended from it or from some common ancestor, but having two longitudinal ridges on the dorsum, and a distinct aperture. *Amastra* is derived from [*Cyclamastra*] which the species resemble during a part or the whole of their

neanic stages. This common ancestor probably was not distinct from [*Cyclamastra*] generically, but must have differed in having a slightly less depressed or longer spire and smaller umbilical perforation, and no distinct carination, the sides being, however, distinctly angulated.

The young shells of these genera have a common form which may in general terms be described as the nepionic or baby shell. This has a comparatively smooth short spire with open columella and broad, stout volutions showing a tendency to angularity on the outer, median zone of the volution and some times an incipient carination. This is particularly obvous in species of *Amastra,* and in *Achatinella phœozona* and *Ach. plumata,* which are both closely allied species.

There is but one form among *Achatinellidæ* that is genetically identical with *Ach. phœozona* and *A. plumata.* This is *Kauaia,* a terrestrial genus of the island of Kauai. This shell has until a very late, probably adult stage, a similar stout form and visible carinations, and its brown color is also in accord with the similar hues of many young shells. The terrestrial genus *Amastra* is obviously in the direct line of descent from *Kauaia,* and has similar colorations and uniform pattern.

Achatinella phœozona, now extinct, was collected by Gulick in the valley of Kuliouou immediately adjoining Niu. This species shows characteristics that intergrade on the one hand with *Bulimella* and on the other with *Achatinella.* It stands at the focus of the affinities of these two groups as regards the form of the shell, which is bulimelloid in some varieties, and Achatinelloid in others; and in the apertures which are plainly Achatinelloid. It also grades into *A. plumata* through numerous hybrids.

Apex cestus and *forbesianus* are both in color and in pattern more like *Achat. plumata* than any other species of the same region, but differ in the characteristic, turbiniform basal volution, the Bulimella-like aperture and the almost constantly dark apex of *Achat. plumata. Achat. plumata* has also the dark apex and is precisely similar to *Ach. porcellana,* which is almost white in the succeeding or nepionic

whorls with similar longitudinal striæ. The conclusion from this and the fact that the young until a late stage have the Achatinelloid form and apertures is obviously in favor of the opinion that Apex sprang from Achatinella and not from Bulimella which it resembles more closely in the aperture.

The close resemblances in the pattern of coloration is in favor of the derivation of *Apex* through *A. plumata* or some closely related modification of this polymorphic species. We can now assume as a working hypothesis that *Achat. phœozona* not only lies at the focus of affinities of these genera but was the surviving representative of their common ancestor. If this be the case the young shells, being nearer to the assumed ancestor, *Kauaia*, ought to carry closer reminiscences of this progenitor and retain its aspect until a later stage of development than *Achat. plumata, Bulimella*, or *Apex.*

This theoretical requirement is actually more exacting than ought to be demanded in view of the fact that *Ach. phœozona* is a more or less remote descendant of this ancestor or proachatinellan shell. Like other actual cases of this kind, it might reasonably be expected that it would have lost or skipped in its development many of the characters of this ancestor. Nevertheless, even the most exacting requirements of the working hypothesis are fulfilled in the ontogeny, and not only the form until a late stage of development is similar to that of *Kauaia*, but the horn-brown and uniform pattern of that genus is also recapitulated in those varieties of *Ach. phœozona* that are not banded.

EXPLANATION OF PLATES.

NOTE.—When not otherwise stated, the specimens figured are in the collection of the Academy of Natural Sciences.

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Part 88, pp. 177-428, plates 40-63, May, 1914.
Preface and Introduction, pp. i-lviii, May, 1914.

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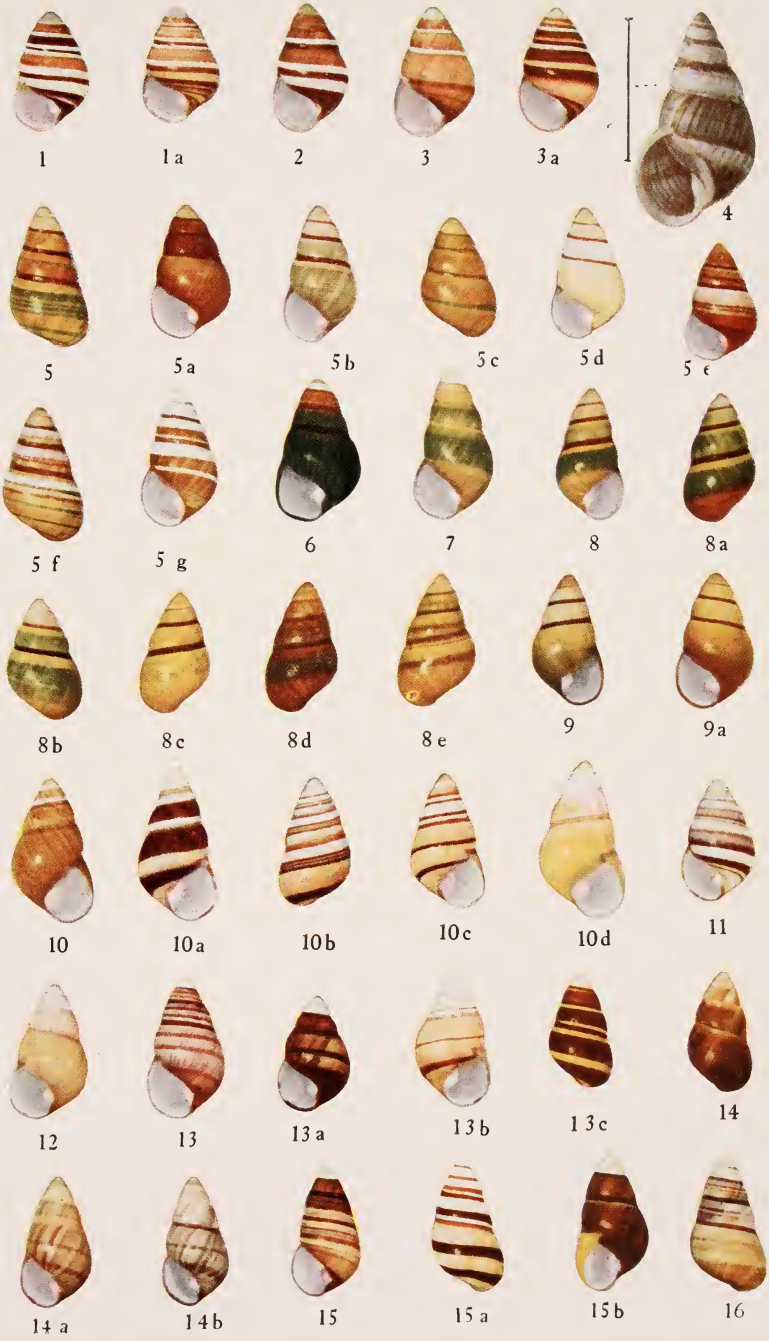
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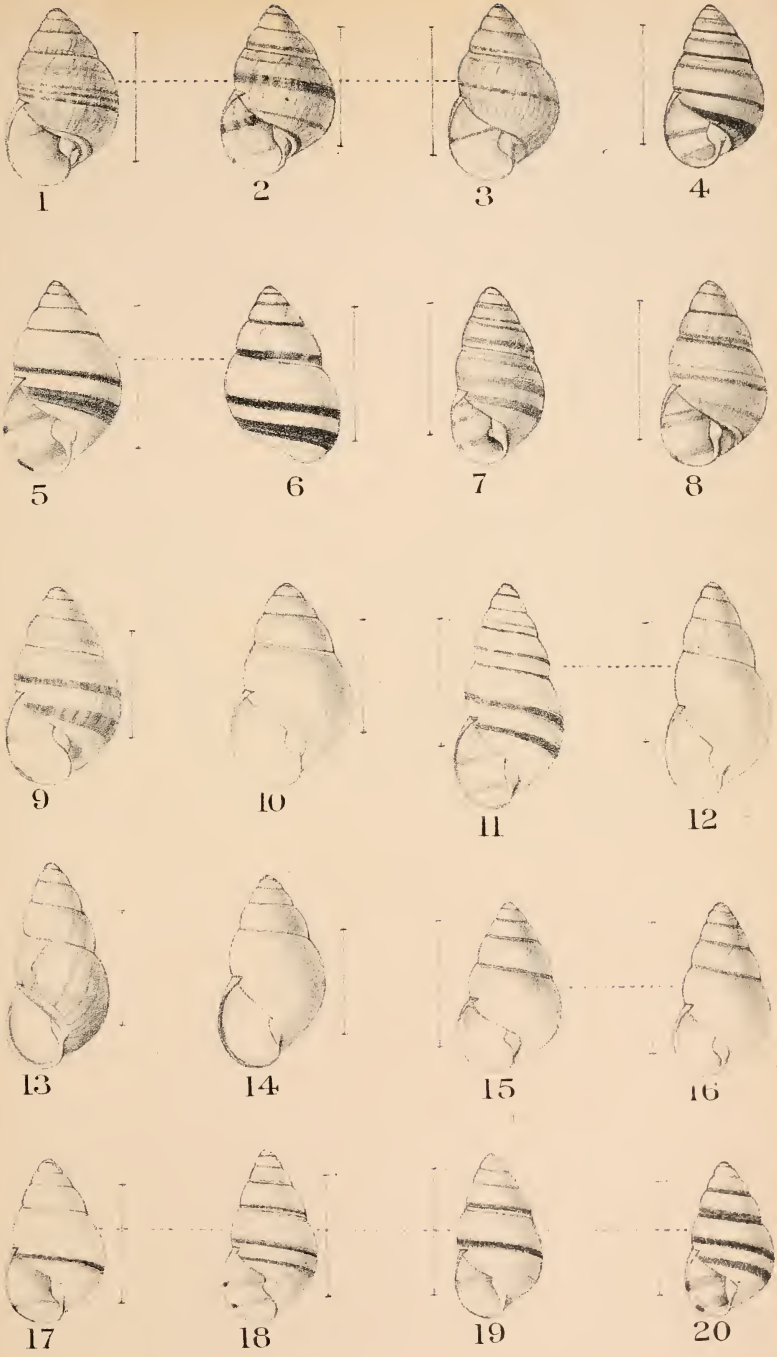
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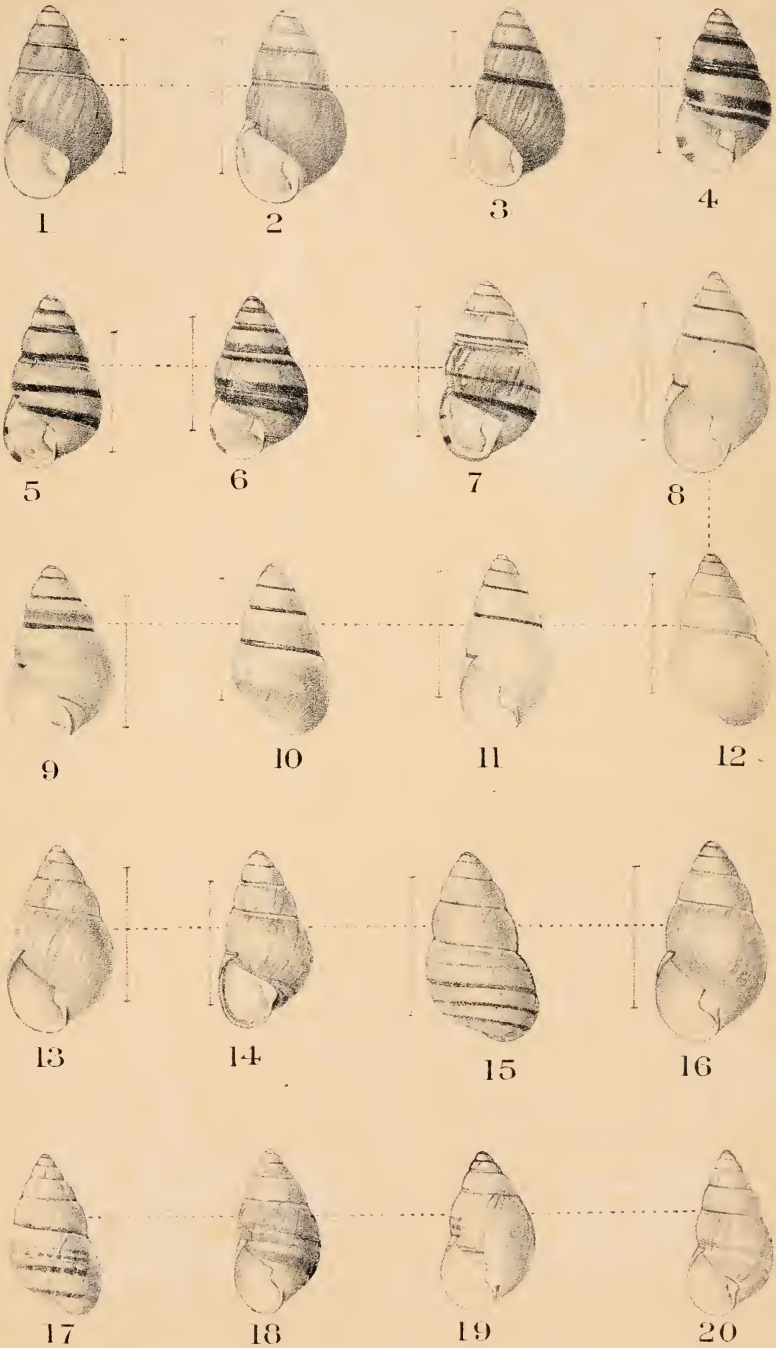
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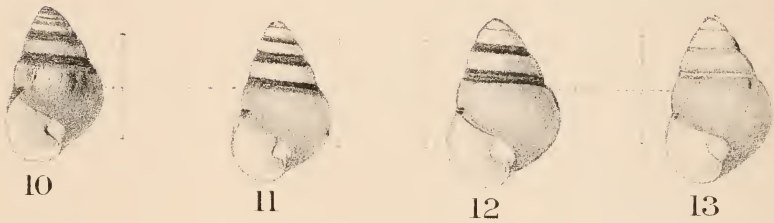
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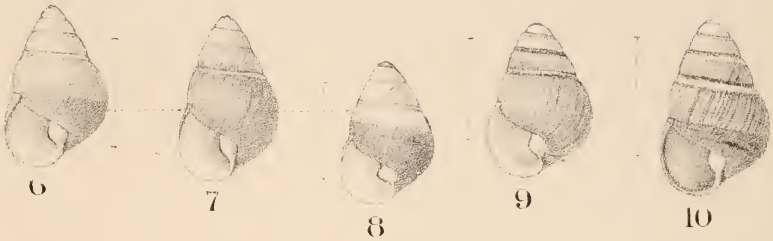
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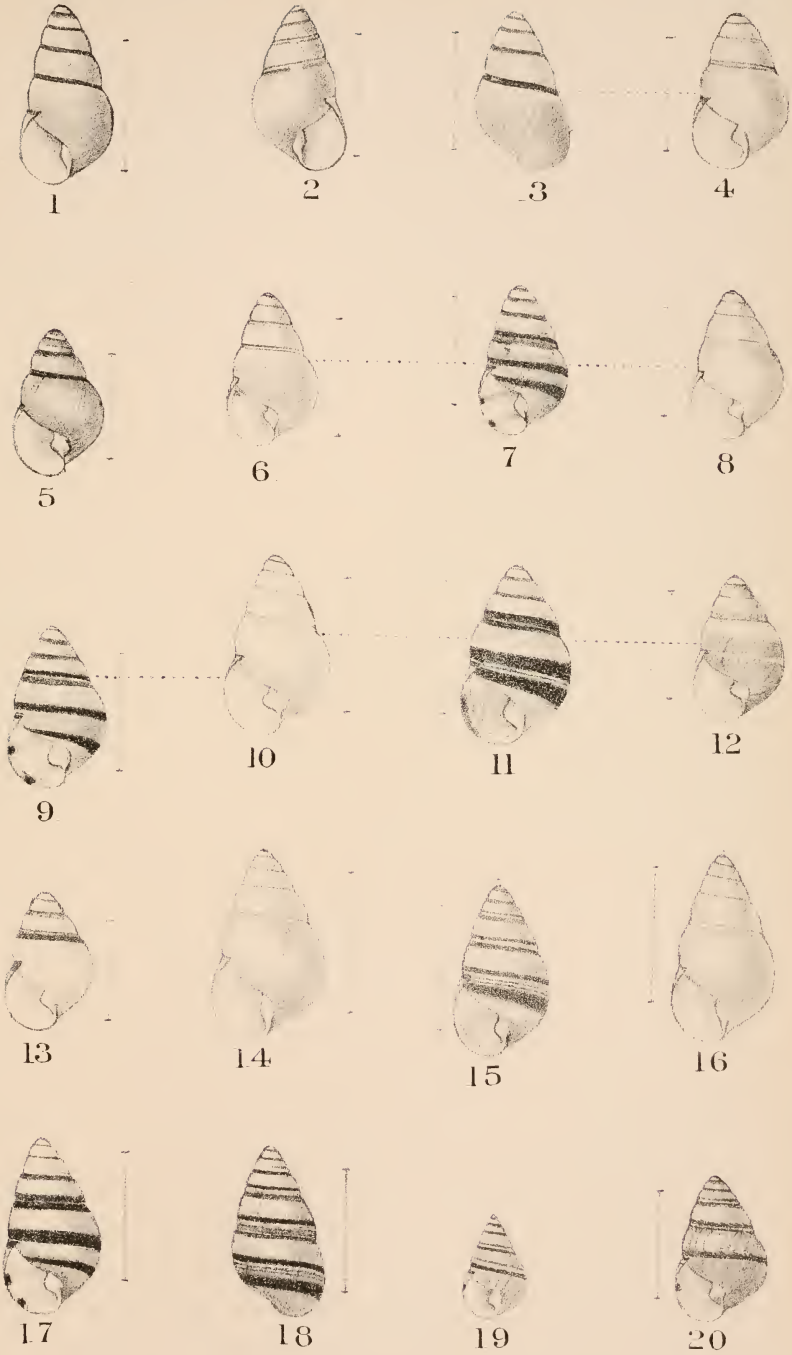
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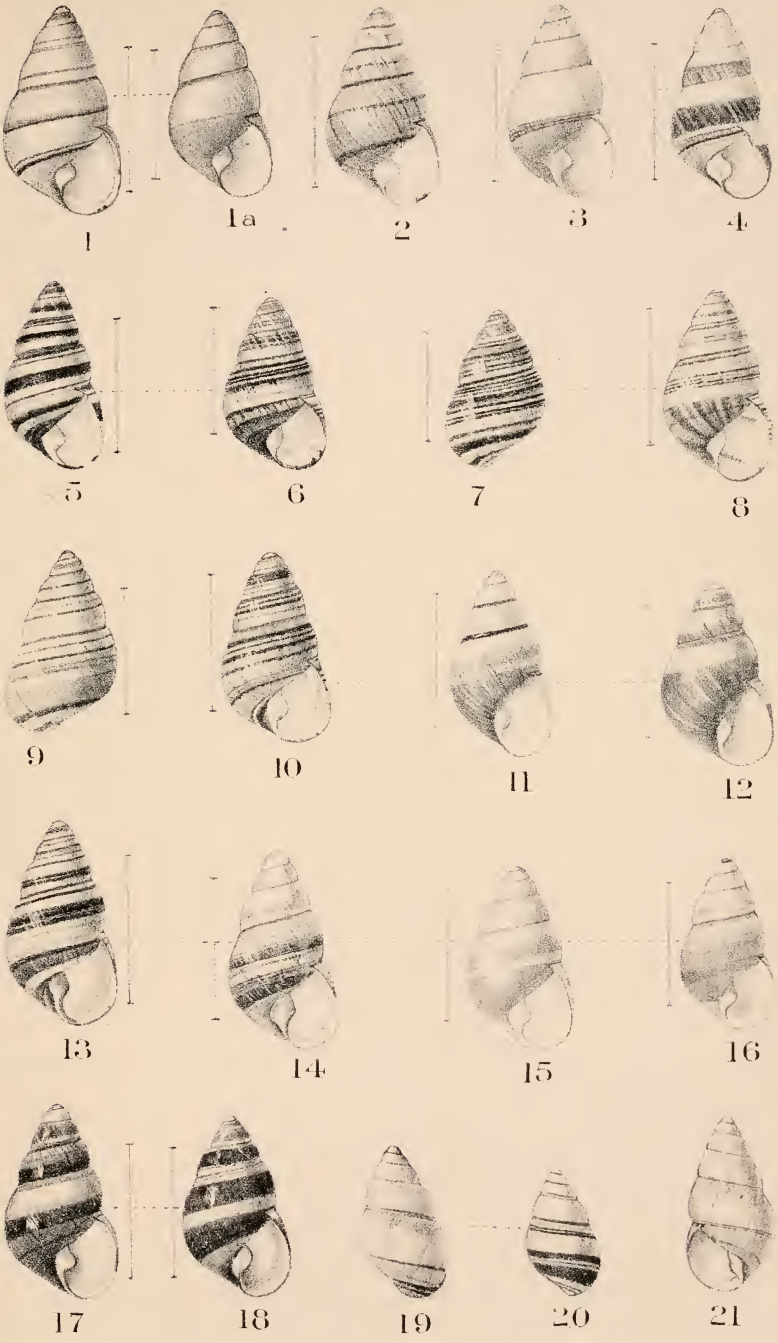
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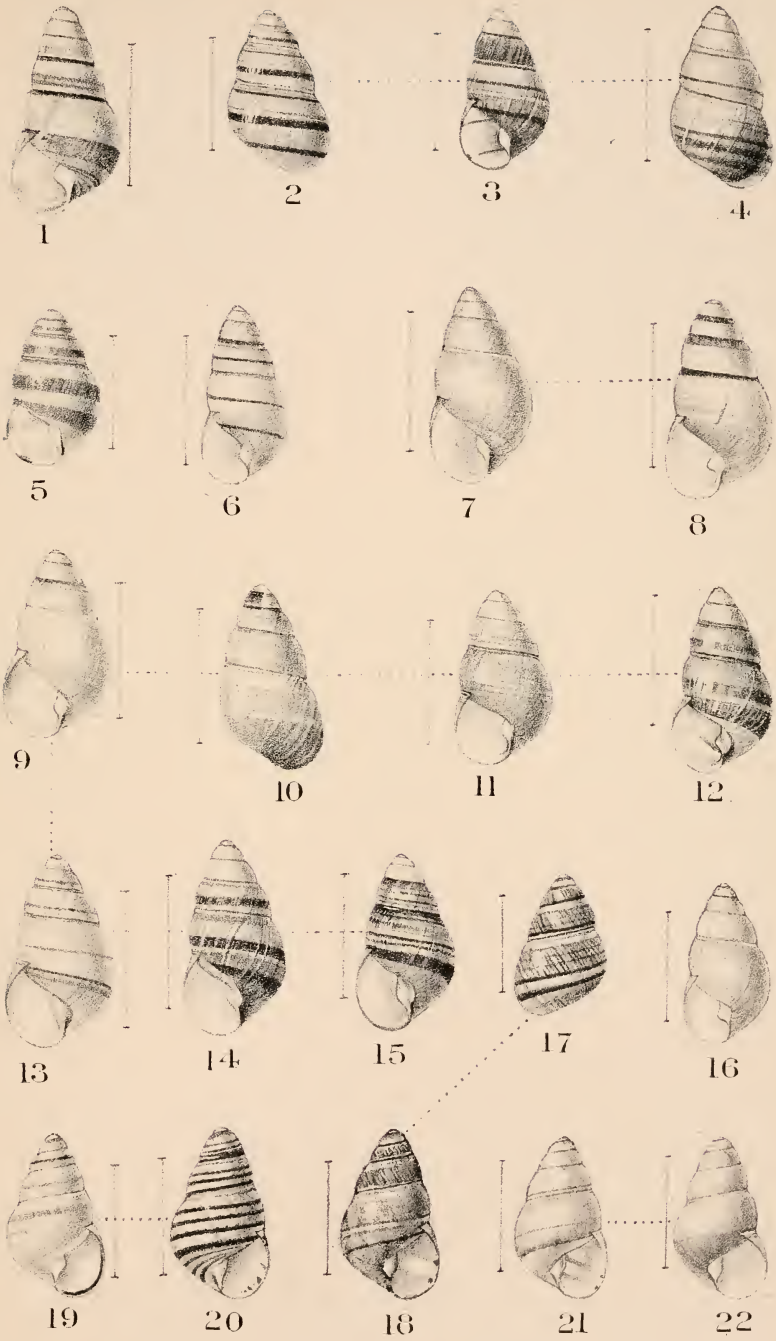
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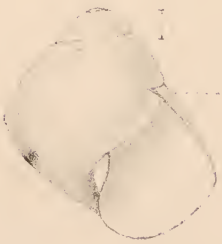
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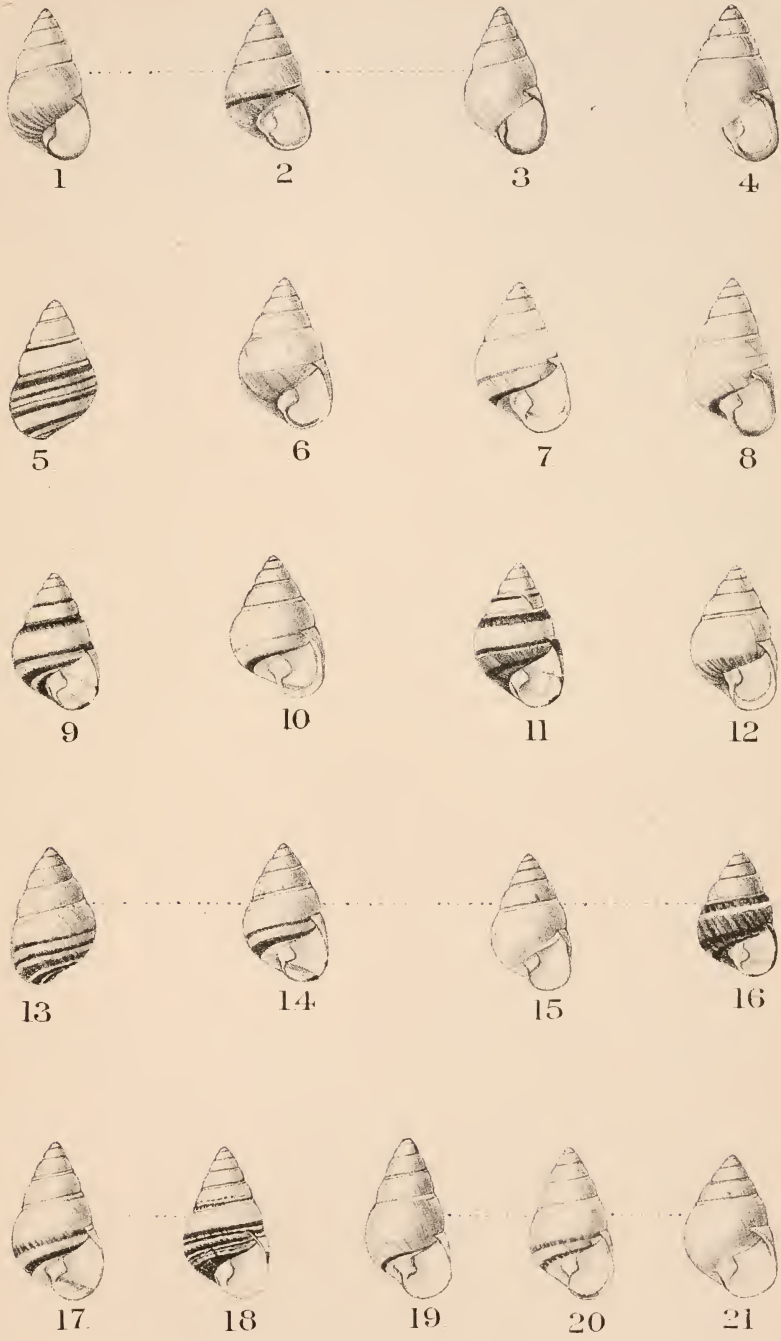
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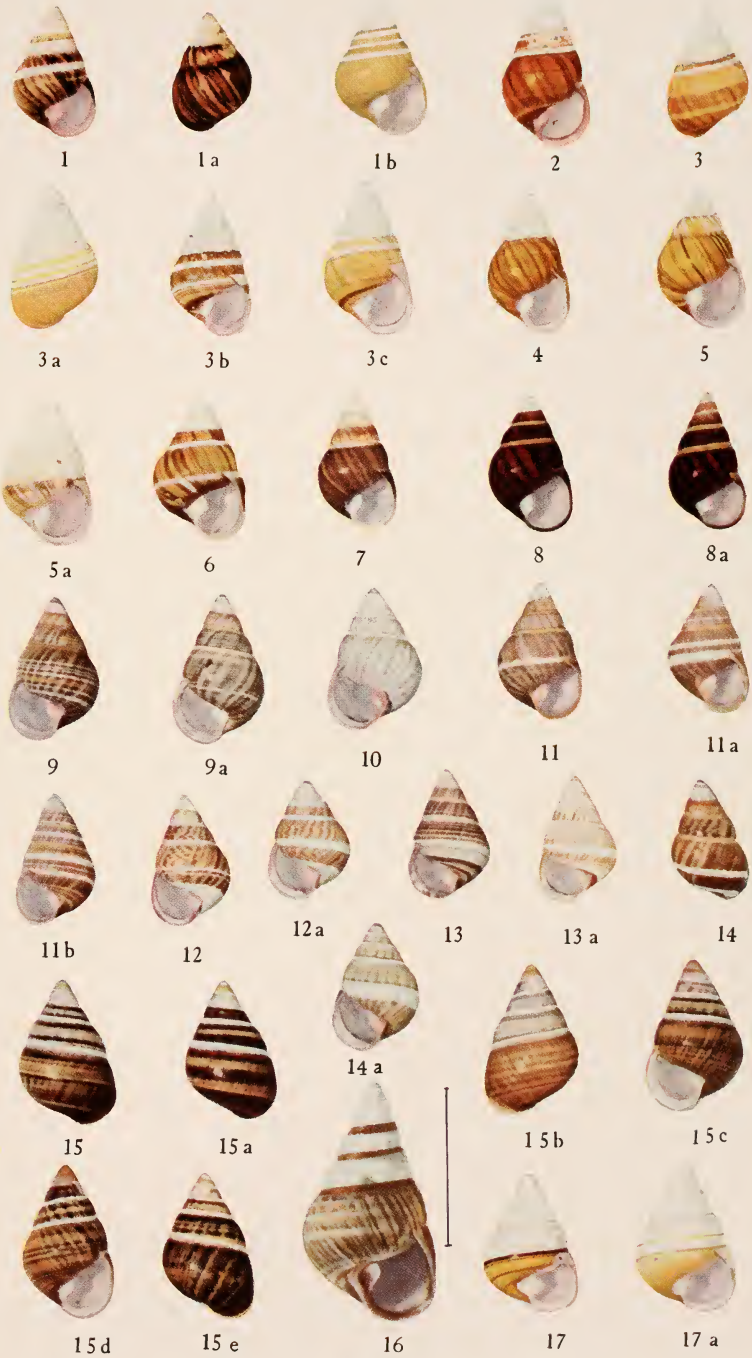
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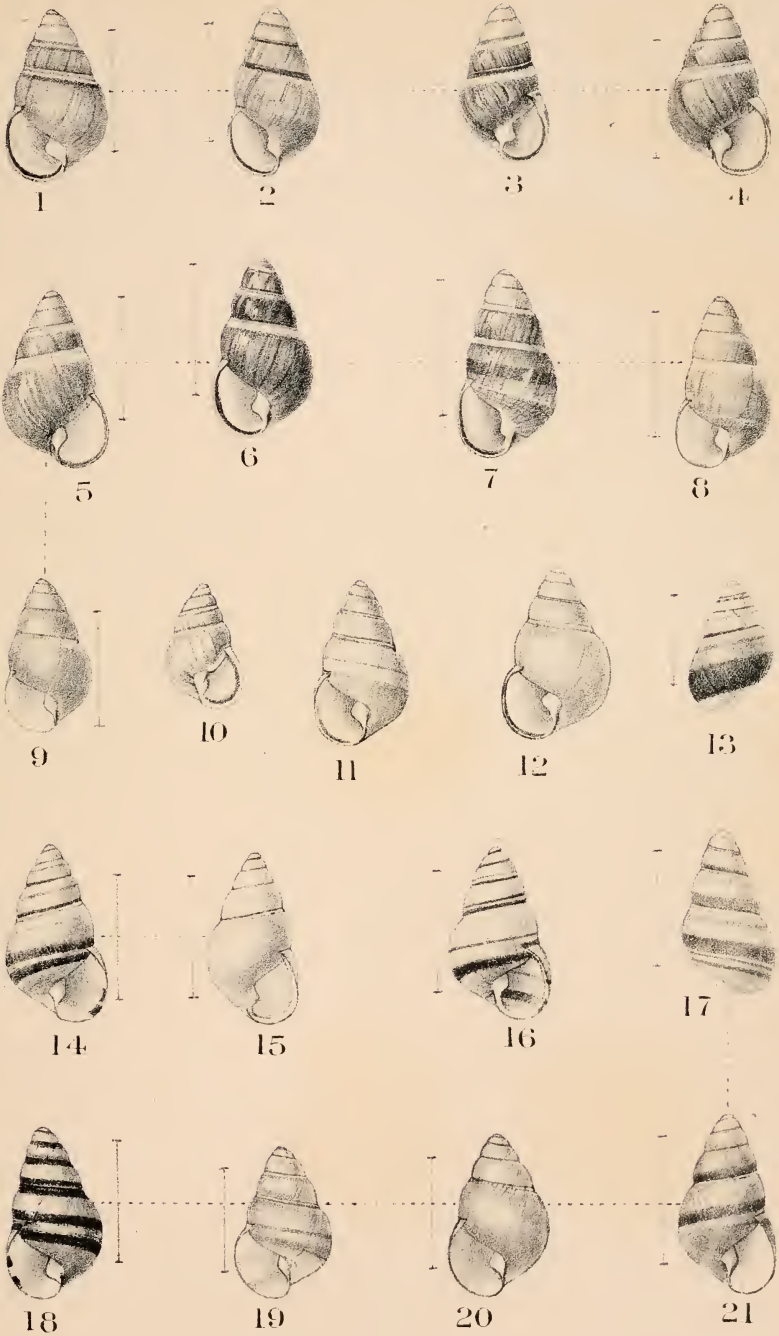
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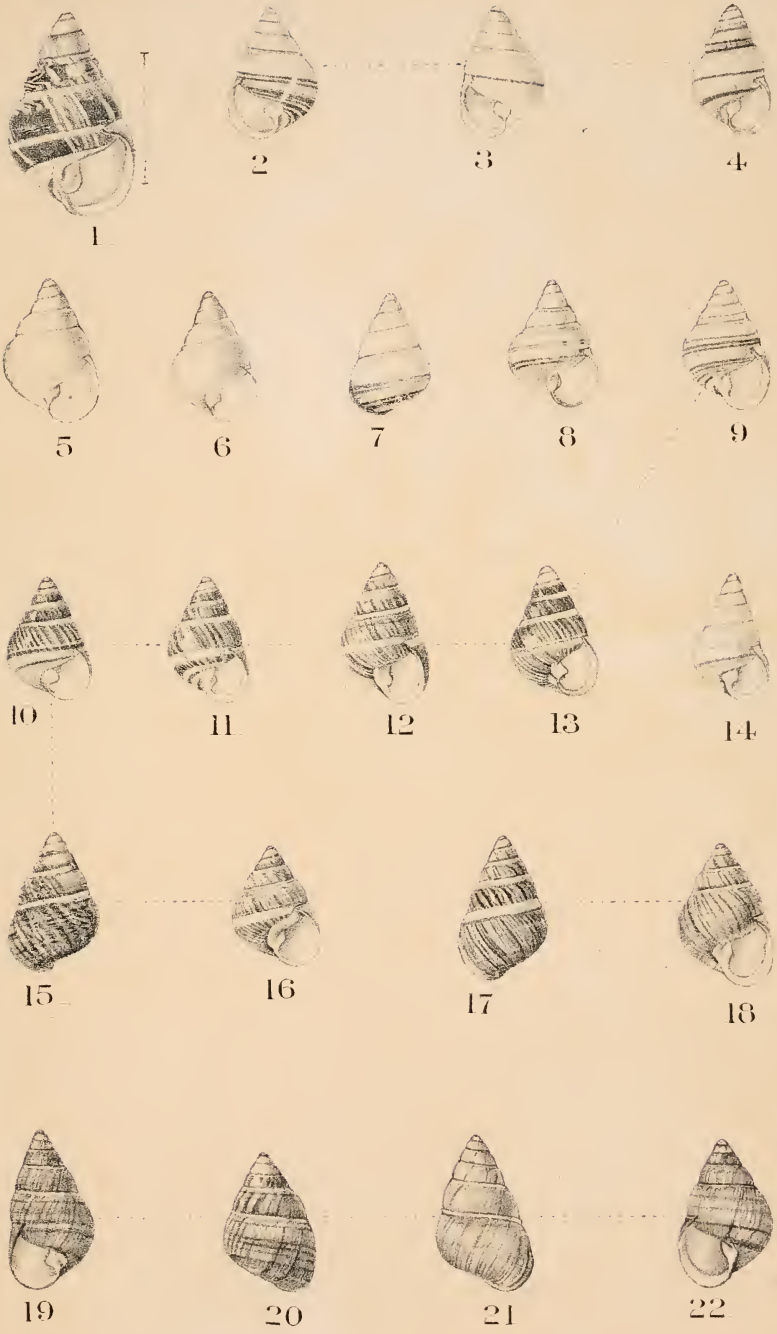
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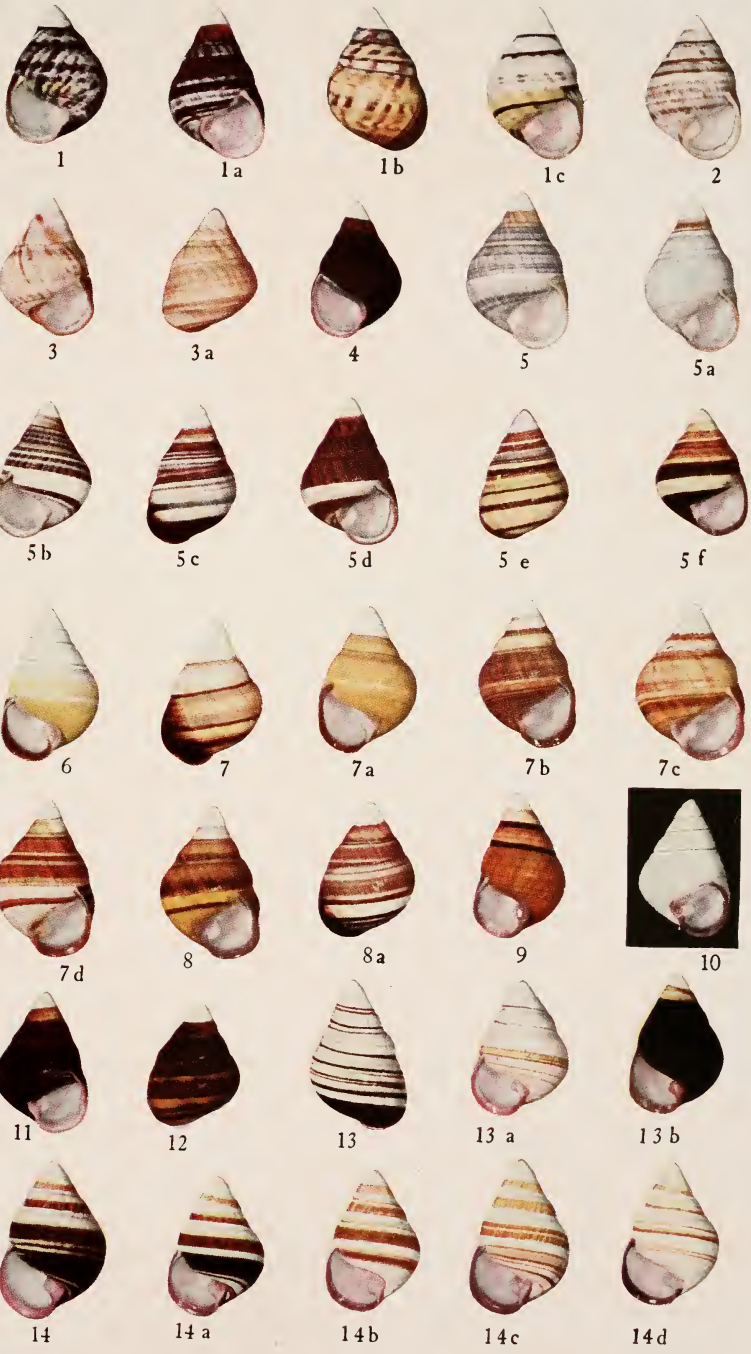
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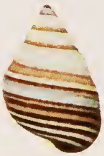
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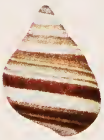
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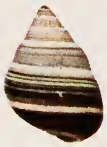
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